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Flotation of Artillery Peak Manganese

Joseph W. Town

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A Thesis

Submitted to the Department of Mineral Dressing
in Partial Fulfillment of the
Requirements for the Degree of
Bachelor of Science in Metallurgical Engineering
Mineral Dressing Option.

Montana School of Mines
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ABSTRACT

The concentration of low-grade manganese ore from Artillery Peak, Arizona, was studied. Flotation with various emulsions failed to yield concentrates of commercial grade, although manganese recoveries of over 90 per cent were obtained.

ACKNOWLEDGMENTS

The writer wishes to express his thanks to Professor Donald McGlashan, Research Professor, and Head of the Department of Mineral Dressing; and Mr. Robert Beebe, Instructor, and Associate Research Engineer of the Department of Mineral Dressing for their help and guidance in the development of this project. Special thanks is also expressed to Manganese, Incorporated, for the ore sample and their helpful suggestions on the project. Further appreciation is also given to the Department of Metallurgy and the Anaconda Company for the use of equipment.

MANGANESE IN INDUSTRY

The major uses of manganese are in the steel, non-ferrous alloy, and chemical industries. Steel production consumes about 95 per cent of the total manganese produced; according to Melcher, in 1950, American industries consumed 774,852 tons of ferro-manganese and 76,280 tons of spiegeleisen. The ore specifications for ferro-manganese are: 48% Mn minimum and a maximum of 6% Fe, 6% SiO_2, 4% Al_2O_3, and 0.12% P (7:8). Copper-manganese alloys for turbine blades and manganese bronze for propellers and other applications where strength and corrosion resistance are required consumed most of the manganese in the nonferrous industries. Manganese in the chemical industries is used as a depolarizer in Leclanche batteries, a dryer in paint pigments, a decolorizer in glass, and a coloring agent in ceramics. The dry-cell industry consumes about two-thirds of the total manganese used in chemical products.

Of the total manganese required in the United States, only about 10 per cent is produced by domestic concerns. The other 90 per cent is imported; primarily from India, Mexico, Cuba, Ghana, and the Union of South Africa, with India alone supplying the United States with over half of its total manganese imports.

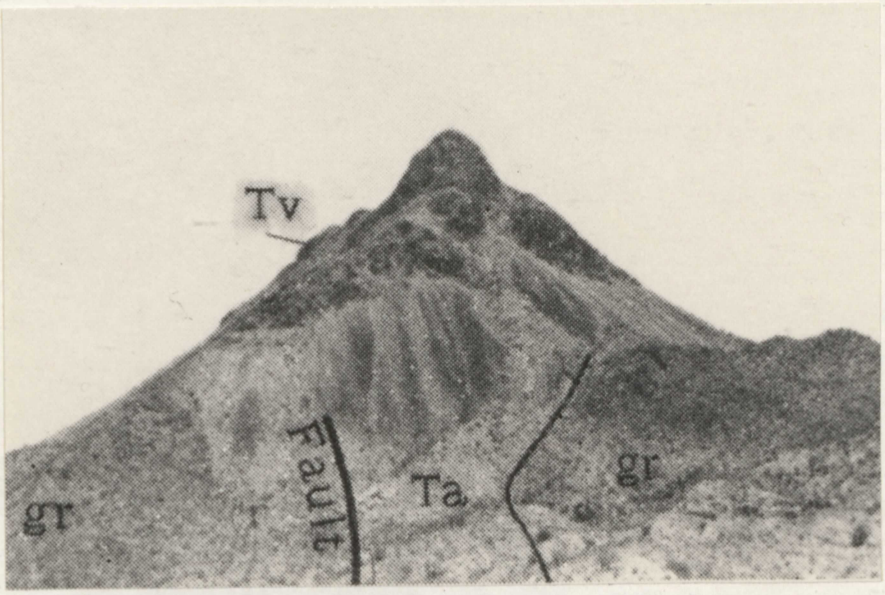
ORE SAMPLE

The ore sample received from Manganese, Incorporated, was obtained from a 2,500 ton sample which the United States Bureau of Mines at Boulder City, Nevada, had mined during 1941 at the Artillery Peak manganese deposit in Mohave County, Arizona.

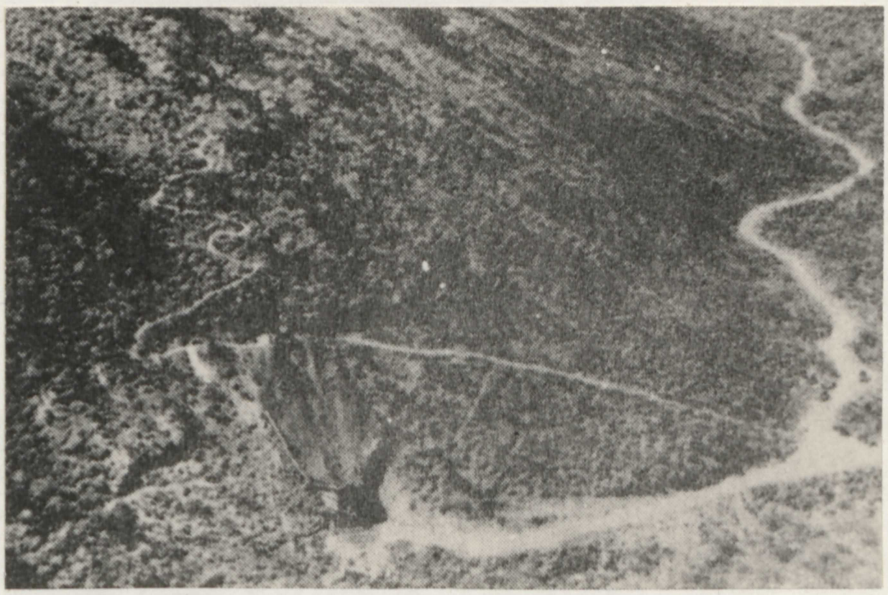
Geography

The Artillery Peak manganese deposit lies between Artillery Peak (Fig. 1) and the Bill Williams River in west central Arizona (Fig. 2). This region is accessible by a fair desert road from Wickenburg, which is 45 miles south of Artillery Peak. During flood stage this road is closed by the Bill Williams River, and traffic must come by way of Yucca. The Santa Fe Railway runs through both of these towns, making them potential shipping points for concentrates if a plant were built in the area.

The average elevation of the region is from 1,200 to 1,500 feet, with the river lying 400 feet lower. This river discharges an average of 122 second-feet of water the year around, with a low of about 8 second-feet during the long dry season (9). During flood stage, the river has been known to discharge 100,000 second-feet of water, which would necessitate the placement of all buildings on high ground. If the supply of water from the



Artillery Peak, showing latite of the Miocene volcanics(Tv) resting on Pre-Cambrian granite(gr) and on basal arkose and conglomerate of the Artillery formation(Ta), which was faulted before emplacement of the latite (4).



Maggie Adit and orebin, in Maggie Canyon (6).

Fig. 1 Artillery Peak and Maggie Adit

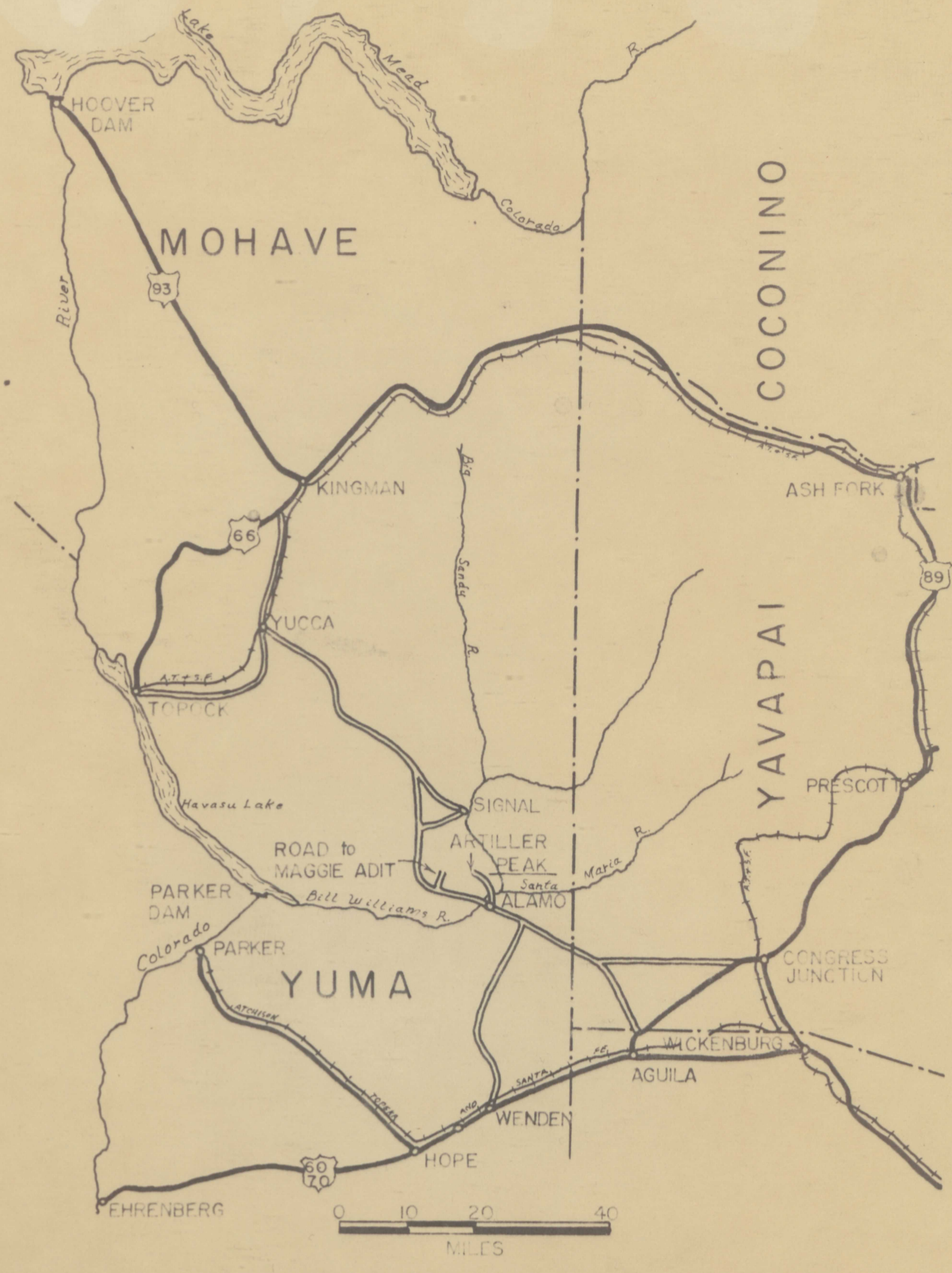


FIG.- 2 ARTILLER PEAK, MOHAVE COUNTY, ARIZONA (6).

Bill Williams River were insufficient for the operation of a concentrating plant, water might be pumped from the Colorado River, 30 miles away.

The climate is hot and dry, with an average rainfall of about 6 inches yearly (6:4). Vegetation is scanty and the only trees are along the Bill Williams River, the desert country having an occasional sahuaro cactus, ocotilla, mesquite or joshua tree.

Geology

The ore deposit is 3 to 5 miles wide and 6 to 7 miles long, lying above coarse-grained granite rocks of Pre-Cambrian age, and either below or intermixed with fresh-water limestone, shale, and sandstone of probably Tertiary age (8:72). The manganiferous oxides are from unknown sources, although some authors believe they originated from hot-springs prior to the volcanic activity, which covered the area with about 100 feet of dark streaked basalt flows (4:423). After the basalt flows considerable faulting took place in what is now the Chapin Wash area, causing the exposure of the deposited manganiferous oxides by erosion.

The ore deposits are classified into three types of rock:

(1) The sandstone ore includes sandstone, conglomerate, and friable siltstone cemented by clay and oxides of manganese and iron. There is no noticable replacement of the sand grains by the manganese and iron oxides. The amorphous manganiferous cement is considered to be wad, with the harder black manganese

oxide called pyrolusite. The sandstone ore reserve amounts to about 40,000,000 tons averaging between 1.5 and 4.0 per cent manganese (5:57).

(2) The clay ore consists of a mixture of clay and mudstone similar to the sandstone ore except that it is considerably finer-grained. This ore lies on the bottom of the manganiferous zone and is remarkably uniform in composition. The clay ore is considered to consist of pyrolusite averaging about 5 per cent manganese (5:58) with reserves considered to be as great as those of the sandstone orebody, although in many places the drill holes did not reach the base of the deposit. This would allow for an even higher estimate of ore reserve.

(3) The hard ore includes manganiferous siltstone, sandstone, and conglomerate, with the original wad manganese having been converted to psilomelane and manganite. The ore was impregnated with opal, calcite, and analcite, after which leaching removed some of the clay and iron oxide, leaving a highly porous orebody. The hard ore will run as high as 20 per cent manganese, with an estimate of about 15,000,000 tons of over 6.5 per cent ore (4:445).

Table I gives an analysis of the three different ores as obtained by the Bureau of Mines at Boulder City, Nevada (5).

TABLE I ORE ANALYSIS OF ARTILLERY PEAK MANGANESE

Constituents	Sandstone Assay, %	Clay Assay, %	Hard Assay, %
Mn	3.5	3.5-4	6.5
Fe	1.5-2.5	3.0-4.0	1.3-5.1
CuO	0.01-0.03	0.05-0.16	0.01-0.05
PbO	0.00-0.17	0.29-0.51	0.0-0.59
ZnO	0.03-0.10	0.09-0.23	0.02-0.10
W-	Trace	Trace	Trace
P_2O_5	0.16-0.19	0.19-0.32	0.08-0.27
BaO	0.65-1.25	0.31-2.13	0.05-4.40
SO_3	0.00-0.28	0.07-3.54	0.0-0.58

Maggie Adit

The Maggie Adit, an experimental mine developed by the United States Bureau of Mines, was driven 185 feet into the side of the Maggie Canyon (Fig.1), to determine the characteristics of the orebody and the best suited mining method to be used if a commercial process was developed for concentration of the ore. The room and piller mining method was selected as the most feasible after many different mining methods had been tried. Considerable difficulty was encountered in drilling and blasting as a result of vugs and soft spots in the ore, which would cause the blasting rounds to bootleg. After the mining work was completed, 2,500 tons of ore were shipped to Boulder City for experimental work. The sample used in these studies came from this ore.

Mineralogy

The manganese minerals as determined by Lasky in the hard ore were manganite and psilomelane (5). Manganite is composed of 62.4 per cent manganese, the formula by Dana is given as $MnO(OH)$ or $Mn_2O_3 \cdot H_2O$. The mineral is usually distinguished from pyrolusite by its prismatic crystals and brown streak. Dana writes the formula for psilomelane as $H_4R_2Mn_8O_{20}$, where R is chiefly Ba. Psilomelane is distinguished from other manganese minerals by its hardness, lack of structure, and curving fractures.

The noncrystalline manganese minerals seem to be deposited on the gangue particles in small nodules, whereas the crystalline manganese is usually found as free particles or as simple locked particles with one side of the manganese connected to one side of the gangue particle (Type I).

FLOTATION BY EMULSION-INDUCED SELECTIVE FLOCCULATION

Studies on the concentration of manganese oxides by emulsion-type reagents have led to the conclusion that selective flocculation is obtained by pH regulation to a level at or near the isoelectric point. The isoelectric point changes with the type of ions that form the Stern layer on the mineral surface. This form of flotation differs from sulfide flotation in that on sulfide minerals the collector after it penetrates the Stern layer, forms a chemical precipitate or physical bond on the mineral surface thus making the mineral surface hydrophobic and air-avid.

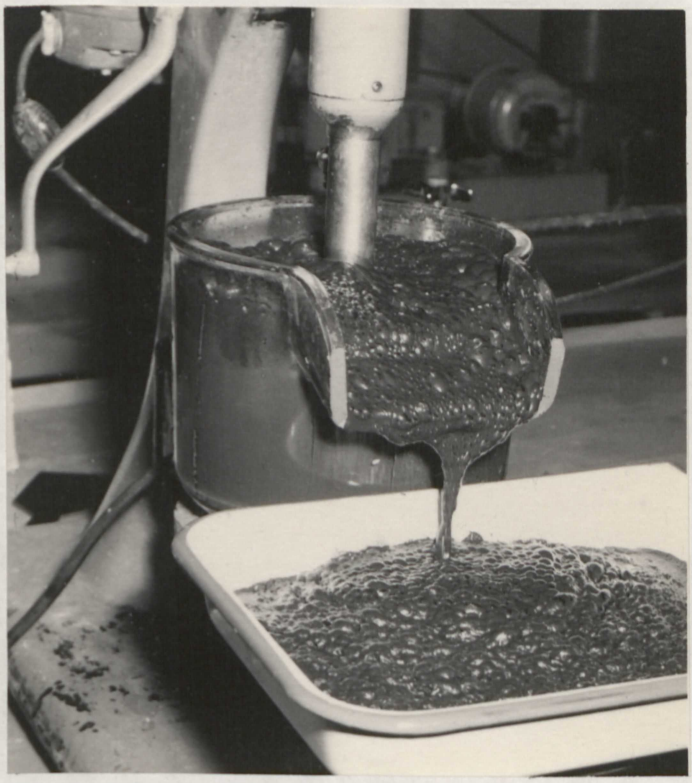
In selective flocculation of manganese by emulsions, the collector is usually a fatty acid or soap containing a carboxyl group. These reagents form a hydrophobic layer on the manganese particles by penetrating the Stern layer and then holding on to the particles, perhaps by Van der Waal's forces. The force holding the collectors to the oxide minerals is not specifically selective, therefore usually more than just the desired oxide mineral floats and only by environmental control can one oxide be preferential floated from the other oxides.

The hydrocarbon ends of the fatty acid or soap are soluble in the oil, which increases the size of the flocs by causing the soap-flocculated particles to be collected around the oil droplets.

These oil droplets are highly air-avid and the neutral hydrocarbon increases the contact angle some 15° to 20° over that of the soap alone.

With the addition of air in the flotation cell, the soap-flocculated particles are lifted to the surface of the cell, where they are either skimmed or floated off as a concentrate, (Fig. 3).

Flocculated manganese after conditioning



Flotation of manganese.

Fig. 3 Float Cells

EXPERIMENTAL WORK

The following sections discuss the work done on the Artillery Peak ore in crushing, grinding, liberating, and floating, in an attempt to produce a commercial-grade concentrate of manganese.

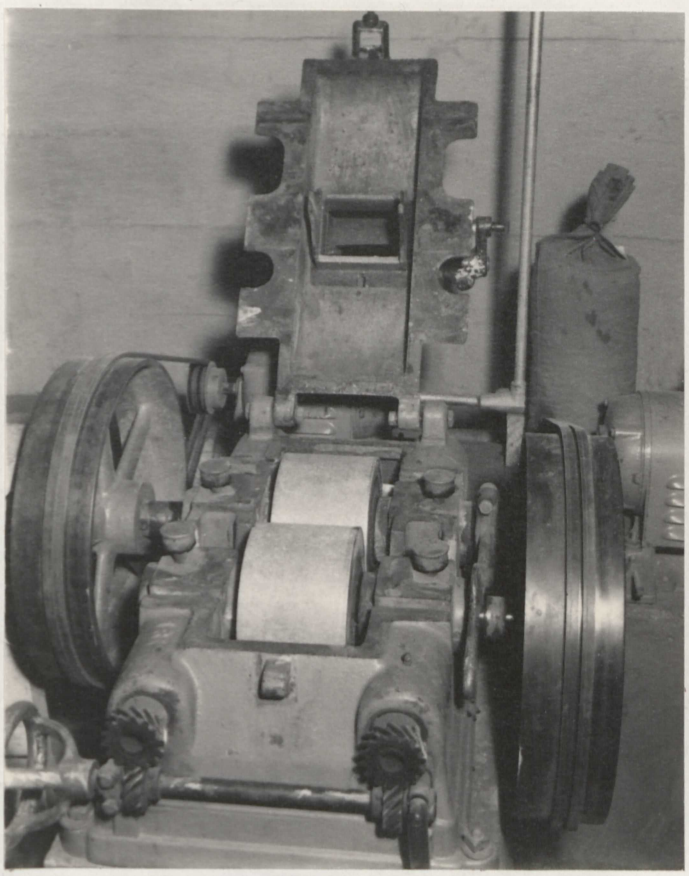
Comminution

The minus ½-in. ore sample was reduced to minus 8 mesh by a laboratory rolls (Fig. 4) in closed circuit with a vibrating screen. The sample was then mixed, sampled, and stored for further use. The moisture content of the sample was not determined.

Two types of grinding were used to reduce the ore to floatable size and to obtain a good degree of liberation of the manganese particles. The grinding method for flotation of the natural ore was conducted in the laboratory rod-mill (Appendix I), with a rod load of 19.5 pounds and 50 per cent solids. The second grinding method, which required a dry product for roasting, was conducted in the pulverizer to a product size of minus 65 mesh. The minus 65 - mesh ore was then roasted and either floated directly after roasting or reground in the rod mill for 5 minutes to produce fresh mineral surfaces for flotation.

Liberation

The ore was ground in the laboratory rod mill for 15 minutes



Laboratory Rolls.

Laboratory Rod Mill.

Fig. 4 Rolls and Rod Mill

to produce the desired mesh size. A particle count was then carried out to determine the number of free and locked particles remaining on each Tyler screen (Appendix I). It was found that, from minus 65 to plus 150 mesh, a considerable number of particles which were about one-fourth manganese and three-fourth gangue were present; the manganese being in the form of small nodules on the gangue particles. These small concretions of manganese seemed to have been broken off below this mesh size however, and it would seem that if abrasion grinding were used these manganese particles might be broken loose from the gangue at an even larger mesh size.

Roasting

To study the response of the different oxides of manganese, it was necessary to roast the Artillery Peak ore in a reducing atmosphere to convert the Mn_2O_3 to MnO and in an oxidizing atmosphere to convert the Mn_2O_3 to MnO_2. A differential thermal analysis (D.T.A.) was then conducted on the roasted and the natural ore to determine the different oxides present (Appendix II).

The thermodynamic reactions for converting Mn_2O_3 to MnO at 800° K are as follows (2):

$$Mn_2O_3 + C \longrightarrow 2MnO + CO \qquad \Delta F = -21{,}000 \text{ cal}$$

$$Mn_2O_3 + CO \longrightarrow 2MnO + CO_2 \qquad \Delta F = -27{,}300 \text{ cal}$$

The roast was conducted at 500° C for 2 hours to allow time for the reaction to take place, after which a D.T.A. was made. The results indicated that the manganese had been reduced to MnO. The exothermic reaction between 400° and 600° C is a result of the excess coal burning off. This manganese is believed to be in the lowest valence state because of the flatness of the graph between 900° and 1000° C.

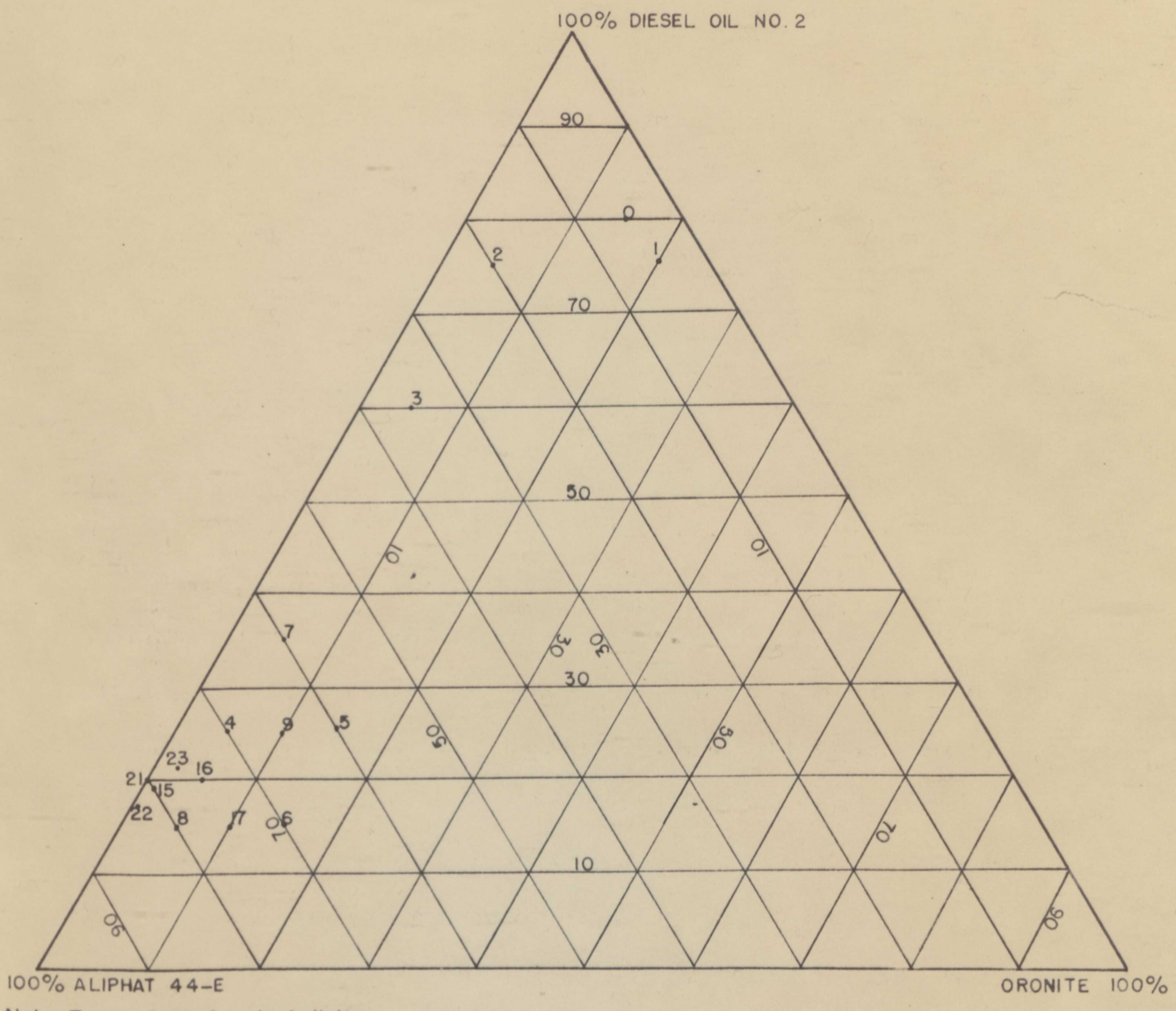
The thermodynamic reaction for the oxidation of Mn_2O_3 to MnO_2 at 400° K or 127° C is as follows (1):

$$Mn_2O_3 + \tfrac{1}{2}O_2 \longrightarrow 2MnO_2 \qquad \Delta F = -9{,}500 \text{ cal}$$

This oxidation roast was made at the most favorable thermodynamic conditions, a temperature of 400° K. The roast was also aided by blowing pure oxygen over the charge while rotating the charge in the furnace for 1 hour. The D.T.A. analysis, however, indicated that the manganese had not been further oxidized and from all indications it would require the building of an oxygen-bomb to put the manganese under a partial pressure of oxygen high enough to force the reaction to take place. This was considered impractical and no further work was done on the oxidation roast.

Flotation of Dry-Ground Natural Ore

Flotation tests conducted on the natural ore were made to determine the optimum reagent combination required to obtain both



Note: Test indicated by last digits.

FIG. 5 TERTIARY DIAGRAM FOR NATURAL ORE TESTS

a high grade and a high recovery of manganese. These tests were plotted on a tertiary graph so that all possible combinations of diesel oil, Aliphat 44-E, and Oronite could be considered if necessary (Fig. 5). The grinding for these tests was done dry in a laboratory pulverizer to minus 65 mesh, so that the natural ore samples would be in contact with water relatively the same length of time as the roasted ore. This procedure made it possible to determine the effect of soluble ions on the flotation tests and also to compare the natural ore tests with the roasted ore tests.

Tests 8007, 8004, 8016, and 8008 show an increasing recovery as the quantity of oil is reduced to 5 pounds per ton, after which the recovery starts to fall off as the quantity of oil is reduced further (Appendix III). When more than 5 pounds per ton of oil was used the impeller and cell became coated with oil, indicating a considerable excess. Therefore, tests were conducted around test 8016 (Fig. 5), with the results proving in test 8021 that Oronite was not required for the flotation of Artillery Peak manganese, in contrast to the manganese ore from Henderson, Nevada.

In summarizing the series of tests for optimum reagent requirements it was found that at a dry grind of minus 65 mesh, a grade of 25 per cent manganese and a manganese recovery of 85 per cent could be expected, with an insoluble grade of about

40 per cent. This required 25 pounds per ton of emulsion which consisted of 20 per cent diesel oil No. 2 and 80 per cent Aliphat 44-E.

Flotation of Wet-Ground Natural Ore

After the optimum emulsion composition had been determined, a series of tests were conducted on the natural ore to determine the amount of emulsion necessary to obtain maximum recovery (Appendix IV). The ore for these tests was ground in the laboratory rod mill for 15 minutes (Appendix I). Figure 6 indicates that maximum recovery is obtained at about 50 pounds per ton of emulsion, with the insoluble grade seeming to reach a maximum at this point, too. An interesting feature of these tests is that with the additional size reduction from the minus 65 mesh grind used for optimum reagent combination to practically all minus 150 mesh for maximum recovery, the grade of manganese with the additional size reduction increased very little; whereas, the insoluble grade dropped almost 10 per cent. If it is assumed that liberation is the limiting factor in the concentration of low-grade manganese, and if it is further assumed that grade is a linear function of size, and a reduction of the top size from 65 mesh (208 microns) to 150 mesh (104 microns) produced a reduction in insoluble grade of 10 per cent, then a size reduction factor of 8 would be required to drop the insoluble grade to 10 per cent of the concentrate. This would require a grind of 26 microns top size, which is probably beyond the operating limits of most commercial plants.

The sharp increase in insoluble grade and recovery resulting from the addition of more emulsion would indicate that if the

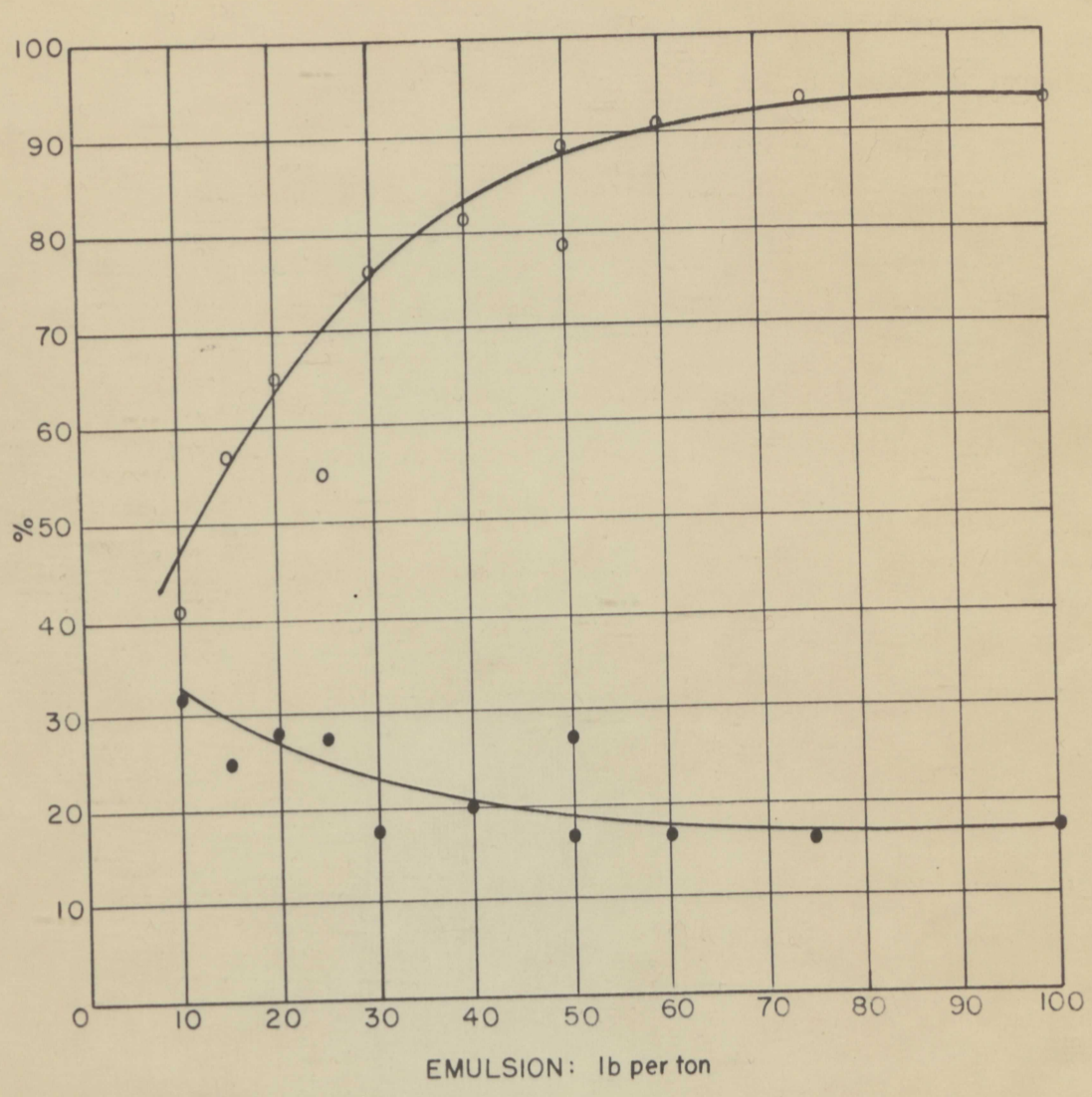


FIG. 6 RECOVERY VS EMULSION CONSUMPTION

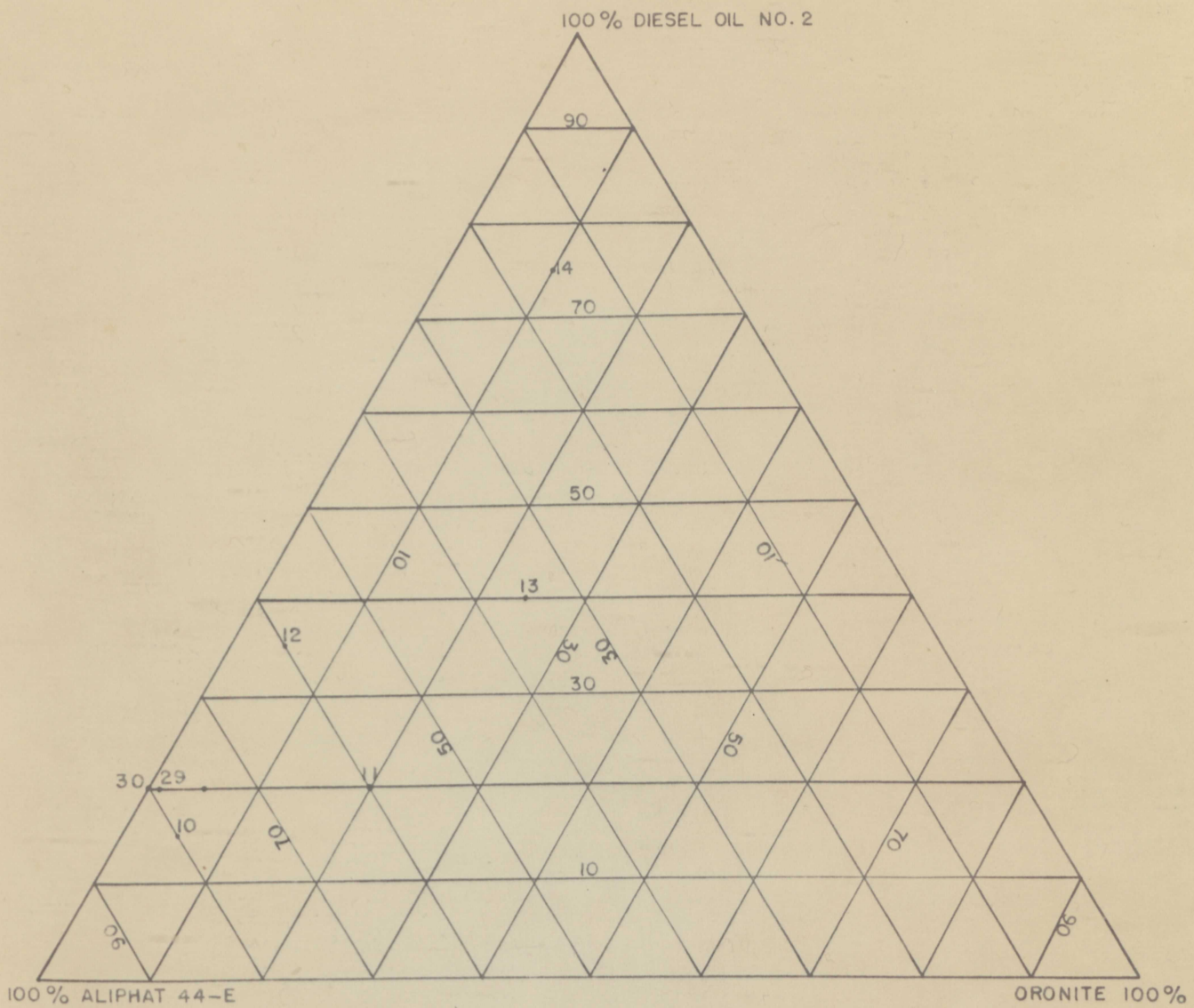
the flotation of manganese is caused by emulsion-induced selective flocculation, a point can be reached where the quantity of reagents is great enough to cause the selective flocculation of gangue particles as well; thus both manganese and gangue would float with the same degree of selectivity.

Flotation of Reduction-Roasted Ore

The data on the flotation tests conducted on the reduction-roasted ore are given in Figure 7 and Appendix V. These tests were very erratic and unpredictable. Tests 8036 and 8037 were reground in the rod mill for 5 minutes to produce fresh mineral surfaces to determine if the insensitivity of the ore was a result of old mineral surfaces caused by roasting. Also, $MgCl_2$ and $SrCl_2$ were added to tests 8031 and 8032 respectively to ascertain if by adding soluble metal ions to the pulp the selective flocculation of the manganese could be reinduced. However, no appreciable increase in grade or recovery of the manganese was obtained by these changes in the standard flotation procedure.

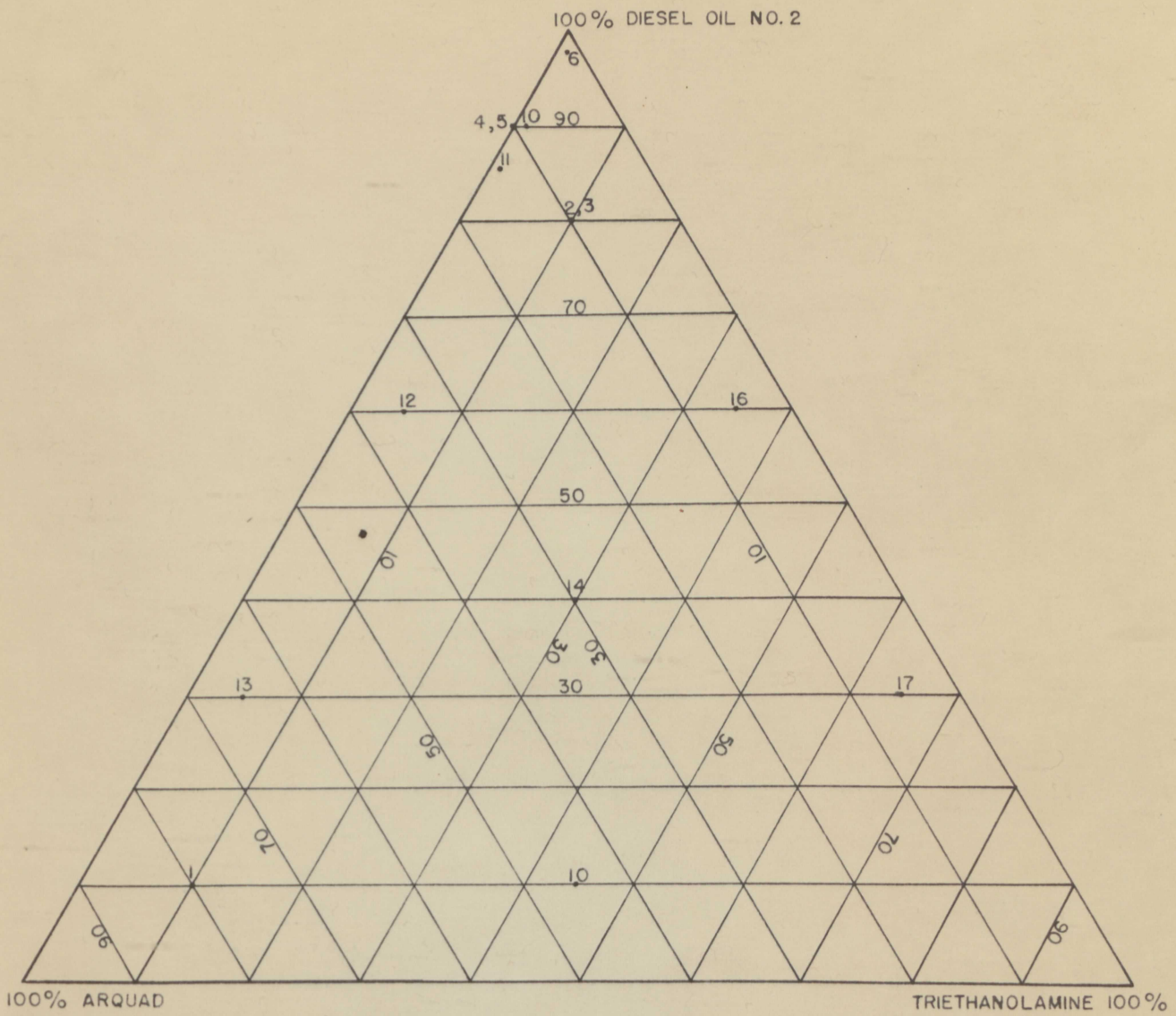
Flotation by a Cationic Collector

The series of tests listed in Figure 8 and Appendix VI were conducted to determine if it was possible to float manganese by means of Arquad 12(lauryl trimethyl ammonium chloride), diesel



Note: Test indicated by last digits

FIG. 7 TERTIARY DIAGRAM FOR REDUCTION ROASTED ORE TESTS



Note: Tests preceded by (C-digit)

FIG. 8 TERTIARY DIAGRAM FOR NATURAL ORE TESTS

oil No. 2, and triethanolamine. These tests were made because of the favorable contact angles obtained on manganese oxide minerals by Arquad 12 and triethanolamine (personal communication with Prof. McGlashan). None of the test products except those from the synthetic mixture were saved because the tests showed complete inability to float an appreciable amount of manganese or gangue. Tests C-18 and C-20 were made using a standard emulsion of oil and soap with the addition of triethanolamine. The results indicated that triethanolamine has some depressing action on the selective flocculation of manganese in an emulsion float.

DISCUSSION OF RESULTS

In discussing the results obtained from the tests made on the Artillery Peak manganese ore, the following points of interest and importance will be considered for the possibility of future flotation work.

1. In view of the relatively constant grade of manganese made by emulsion-induced selective flocculation, it would seem advisable to use the standard emulsion at a fixed ration of soap to oil and to each of these tests add modifying reagents such as depressents, activators, dispersents, and pH regulators to investigate the possibility of finding some reagent combination that will produce a high grade concentrate. This could be followed by a study aimed at increasing the recovery, provided some way of increasing the grade could be found.

2. As was mentioned in the discussion of liberation, a study of abrasion grinding would be very worth while to determine if it is possible to liberate the manganese at a coarser grind by abrading the manganese concretions from the gangue particles.

3. There appears to be no advantage in roasting the manganese ore. The reason for the low recovery must be either related to the old surfaces produced as a result of roasting or to some sensitizing agent that is made ineffective by the roasting process.

4. Another interesting study which would help in the

understanding of selective flocculation of manganese would be to investigate Arquad 12, which does not float the manganese ore as the contact angle would indicate.

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Appendix I

Grinding and Liberation Studies

The ore for flotation was ground in a laboratory Galigher rod mill with a rod load consisting of 8 rods 3/4-in. in diameter, 8 rods 5/8-in. in diameter, and 8 rods 1/2-in. in diameter weighing 19.5 lb. The wet screen analysis, made on 400 g of ore, ground at 50 per cent solids, is given on the following page.

The liberation studies were made on each Tyler screen size with 300 gangue particles being counted to insure a high degree of accuracy. The results are listed on the following page.

Grinding Analysis

Grind	5 min		10 min		15 min		20 min	
Mesh	wt	% wt	wt	% wt	wt	% wt	wt	% wt
65	0.6	0.2						
100	28.0	7.0	0.7	0.2				
150	67.9	17.0	17.4	4.3	4.2	1.1	0.8	0.2
200	74.4	18.6	52.8	13.2	28.4	7.1	12.8	3.2
-200	229.0	57.2	329.1	82.3	367.4	91.8	386.4	96.6
Total	400.0	100.0	400.0	100.0	400.0	100.0	400.0	100.0

Liberation Analysis

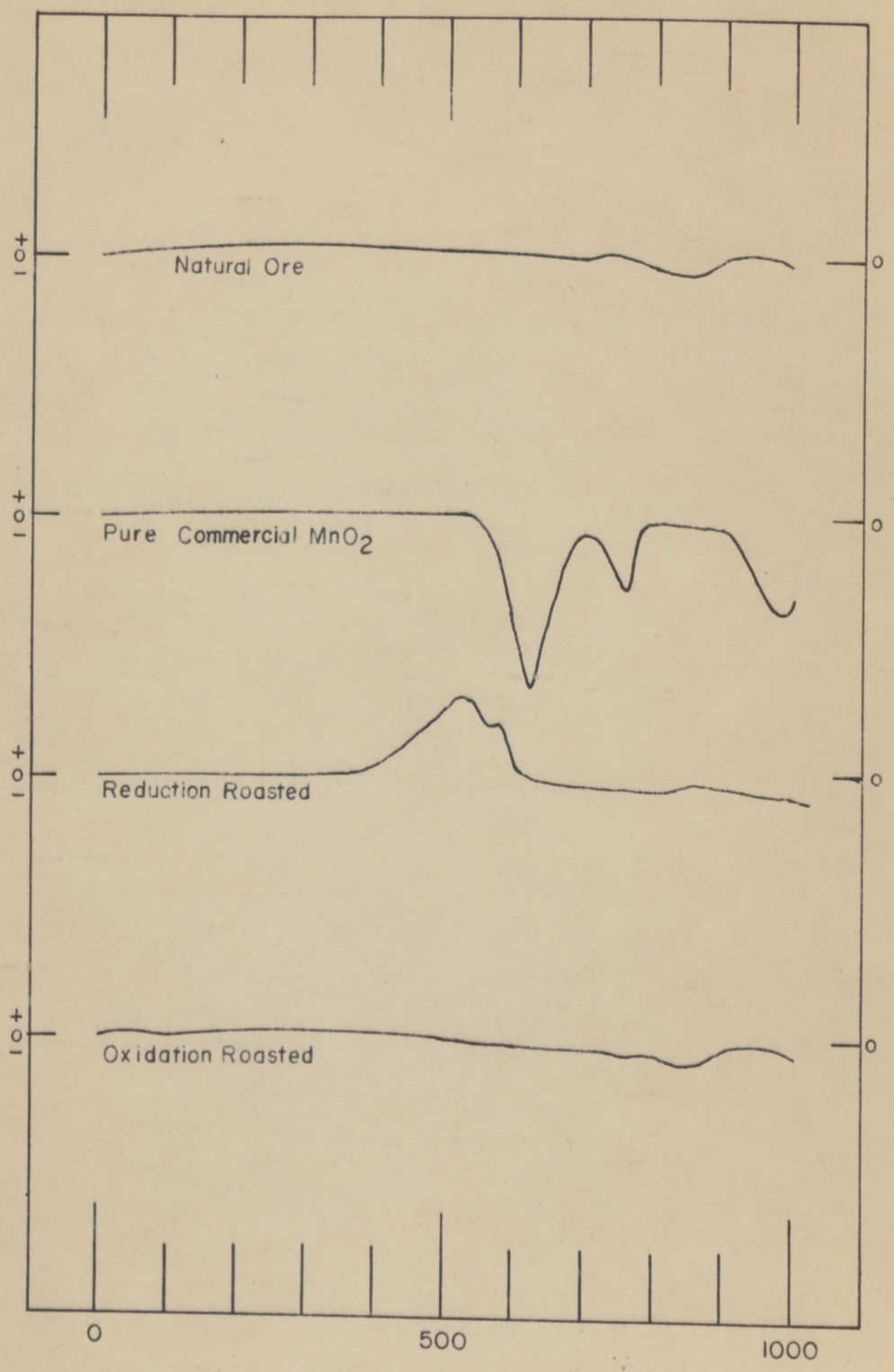
by particle count

Mesh	All Mn	3/4 Mn	1/2 Mn	1/4 Mn	No Mn
65	38	21	32	34	300
100	37	5	36	120	300
150	47	7	16	112	300
200	75	5	35	35	300
-200	73	3	20	12	300

Appendix II

Differential Thermal Analysis

In determining the different oxides of manganese a differential thermal analysis was made on the different ore products at the Anaconda "Geological Laboratory" in Butte. The tests were made by plotting the change in sample temperature in millivolts against the temperature of the furnace, with the area above or below the zero level being directly proportional to the percentage change of each oxide.



°C TEMPERATURE

DIFFERENTIAL THERMAL ANALYSIS

Appendix III

Flotation Tests of Dry-Ground Natural Ore

Test: 8000

Ore: Natural

Grind:	Mill	Time	Mesh	Percent Solids
	Pulverizer	min	All -65	100 %

Fagergren Flotation Machines:	Conditioned	Floated
	15 min at 2200 rpm	at 1220 rpm

Reagents	Pounds per ton	
	Rougher	Cleaner
SO_2 for pH of 6.0	8.5 #/T	
Emulsion Composition	100.0 #/T	
80% Diesel Oil #2	80.0 #/T	
15% Aliphat 44-D	15.0 #/T	
5% Cronite	5.0 #/T	

Products	Wt	% Wt	Assays		Recovery	
			% Mn	% Insol	% Mn	% Insol
Cl. Conc.						
Middling						
Tailing						
Head calc.						
Head assay						

Initial...pH- 8.1

SO_2.....pH- 4.9

Emulsion..pH- 6.2

Final.....pH-

Remarks: This test was not saved for assay because of the poor froth.

Test: 8001

Ore: Natural

Grind:	Mill	Time	Mesh	Percent Solids
	Pulverizer	min	All -65	100 %

Fagergren Flotation Machines:	Conditioned	Floated
	15 min at 2200 rpm	at 1220 rpm

Reagents	Pounds per ton	
	Rougher	Cleaner
SO_2 for pH of 6.0	5.0 #/T	
Emulsion Composition	100.0 #/T	
75% Diesel Oil #2	75.0 #/T	
20% Aliphat 44-D	20.0 #/T	
5% Oronite	5.0 #/T	

Products	Wt	% Wt	Assays		Recovery	
			% Mn	% Insol	% Mn	% Insol
Cl. Conc.						
Middling						
Tailing						
Head calc.						
Head assay						

Initial...pH-8.3

SO_2.....pH-5.1

Emulsion..pH-6.9

Final.....pH-

Remarks: Test was too oily, so was not saved.

Test: 8002

Ore: Natural

Grind:	Mill	Time	Mesh	Percent Solids
	Pulverizer	min	All -65	100 %

Fagergren Flotation Machines:	Conditioned	Floated
	10 min at 2200 rpm	at 1220 rpm

Reagents	Pounds per ton	
	Rougher	Cleaner
SO_2 for pH of 6.0	2.0 #/T	
Emulsion Composition	100.0 #/T	
75% Diesel Oil #2	75.0 #/T	
20% Aliphat 44-D	20.0 #/T	
5% Oronite	5.0 #/T	

Products	Wt	% Wt	Assays		Recovery	
			% Mn	% Insol	% Mn	% Insol
Cl. Conc.	95.6	25.0	28.8	28.6	76.2	10.0
Middling	101.7	26.5	4.0	81.3	17.1	30.3
Tailing	185.7	48.5	1.3	87.6	6.7	59.7
Head calc.	383.0	100.0			100.0	100.0
Head assay			9.2	71.0		

Initial...pH-8.2

SO_2.....pH-5.5

Emulsion..pH-7.3

Final.....pH-

Remarks: The froth was still oily.

Test: 8003

Ore: Natural

Grind:	Mill	Time	Mesh	Percent Solids
	Rod	10 min	All -65	40 %

Fagergren Flotation Machines:	Conditioned	Floated
	10 min at 2200 rpm	at 1220 rpm

Reagents	Pounds per ton	
	Rougher	Cleaner
SO_2 for pH of 6.0	2.0 #/T	
Emulsion Composition	100.0 #/T	
60% Diesel Oil #2	60.0 #/T	
35% Aliphat 44-D	35.0 #/T	
5% Oronite	5.0 #/T	

Products	Wt	% Wt	Assays		Recovery	
			% Mn	% Insol	% Mn	% Insol
Cl. Conc.	113.2	28.8	27.3	28.4	85.8	12.5
Middling	154.1	39.1	2.5	98.4	10.7	58.5
Tailing	126.6	22.1	1.5	86.0	3.6	29.0
Head calc.	393.9	100.0			100.0	100.0
Head assay			9.2	71.0		

Initial...pH- 8.3

SO_2.....pH-

Emulsion..pH- 7.7

Final.....pH-

Remarks: Test was somewhat oily.

Test: 8004

Ore: Natural

Grind:	Mill	Time	Mesh	Percent Solids
	Pulverizer	min	All -65	100 %

Fagergren Flotation Machines:	Conditioned	Floated
	10 min at 2200 rpm	at 1220 rpm

Reagents	Pounds per ton	
	Rougher	Cleaner
SO_2 for pH of 6.0	2.0 #/T	
Emulsion Composition	25.0 #/T	
25% Diesel Oil #2	6.25#/T	
70% Aliphat 44-E	17.5 #/T	
5% Oronite	1.25#/T	

Products	Wt	% Wt	Assays		Recovery	
			% Mn	% Insol	% Mn	% Insol
Cl. Conc.	106.5	27.5	24.4	35.6	79.1	13.6
Middling	80.2	20.7	4.9	80.0	13.6	23.1
Tailing	200.5	51.8	1.2	88.1	7.3	63.3
Head calc.	387.2	100.0			100.0	100.0
Head assay			9.2	71.0		

Initial...pH-8.2 Remarks:

SO_2.....pH-6.0

Emulsion..pH-7.1

Final.....pH-

Test: 8005

Ore: Natural

Grind:	Mill	Time	Mesh	Percent Solids
	Pulverizer	min	All -65	100 %

Fagergren Flotation Machines:	Conditioned	Floated
	10 min at 2200 rpm	at 1220 rpm

Reagents	Pounds per ton	
	Rougher	Cleaner
SO_2 for pH of 6.0	2.0 #/T	
Emulsion Composition	25.0 #/T	
25% Diesel Oil #2	6.25#/T	
60% Aliphat 44-E	15.0 #/T	
15% Oronite	3.75#/T	

Products	Wt	% Wt	Assays		Recovery	
			% Mn	% Insol	% Mn	% Insol
Cl. Conc.	115.6	29.4	24.5	36.0	82.2	15.1
Middling	81.0	20.6	4.2	81.2	9.8	23.8
Tailing	196.3	50.0	1.4	85.7	8.0	61.1
Head calc.	392.9	100.0			100.0	100.0
Head assay			9.2	71.0		

Initial...pH-8.3 Remarks:

SO_2.....pH-5.7

Emulsion..pH-7.0

Final.....pH-

Test: 8006

Ore: Natural

Grind:	Mill	Time	Mesh	Percent Solids
	Pulverizer	min	All -65	100 %

Fagergren Flotation Machines:	Conditioned	Floated
	10 min at 2200 rpm	at 1220 rpm

Reagents	Pounds per ton	
	Rougher	Cleaner
SO_2 for pH of 6.0	2.0 #/T	
Emulsion Composition	25.0 #/T	
15% Diesel Oil #2	3.75#/T	
70% Aliphat 44-E	17.5 #/T	
15% Oronite	3.75#/T	

Products	Wt	% Wt	Assays		Recovery	
			% Mn	% Insol	% Mn	% Insol
Cl. Conc.	131.2	33.6	21.9	41.5	82.7	19.6
Middling	73.7	19.0	3.8	82.4	8.1	22.0
Tailing	185.8	47.4	1.7	87.0	9.2	58.4
Head calc.	390.7	100.0			100.0	100.0
Head assay			9.2	71.0		

Initial...pH-8.2 Remarks:

SO_2.....pH-5.8

Emulsion..pH-7.0

Final.....pH-

Test: 8007

Ore: Natural

Grind:	Mill	Time	Mesh	Percent Solids
	Pulverizer	min	All -65	100 %

Fagergren Flotation Machines:	Conditioned	Floated
	10 min at 2200 rpm	at 1220 rpm

Reagents	Pounds per ton	
	Rougher	Cleaner
SO_2 for pH of 6.0	2.0 #/T	
Emulsion Composition	25.0 #/T	
35% Diesel Oil #2	8.75#/T	
60% Aliphat 44-E	15.0 #/T	
5% Oronite	1.25#/T	

Products	Wt	% Wt	Assays		Recovery	
			% Mn	% Insol	% Mn	% Insol
Cl. Conc.	88.7	22.6	29.2	27.4	74.2	8.6
Middling	71.5	18.2	8.1	72.4	16.5	18.4
Tailing	231.8	59.2	1.4	88.8	9.3	73.0
Head calc.	392.0	100.0			100.0	100.0
Head assay			9.2	71.0		

Initial...pH- 8.1 Remarks:

SO_2.....pH- 6.0

Emulsion..pH- 7.2

Final.....pH-

Test: 8008

Ore: Natural

Grind:	Mill	Time	Mesh	Percent Solids
	Pulverizer	min	All -65	100 %

Fagergren Flotation Machines:	Conditioned	Floated
	10 min at 2200 rpm	at 1220 rpm

Reagents	Pounds per ton	
	Rougher	Cleaner
SO_2 for pH of 6.0	2.0 #/T	
Emulsion Composition	25.0 #/T	
15% Diesel Oil #2	3.75#/T	
80% Aliphat 44-E	20.0 #/T	
5% Oronite	1.25#/T	

Products	Wt	% Wt	Assays		Recovery	
			% Mn	% Insol	% Mn	% Insol
Cl. Conc.	122.5	31.4	24.3	38.4	83.7	16.8
Middling	80.8	20.7	3.7	84.1	8.4	24.4
Tailing	187.1	47.9	1.5	88.0	7.9	58.8
Head calc.	390.4	100.0			100.0	100.0
Head assay			9.2	71.0		

Initial...pH- 8.2 Remarks:

SO_2.....pH- 6.1

Emulsion..pH- 6.9

Final.....pH-

Test: 8009

Ore: Natural

Grind:	Mill	Time	Mesh	Percent Solids
	Pulverizer	min	All -65	100 %

Fagergren Flotation Machines:	Conditioned	Floated
	10 min at 2200 rpm	at 1220 rpm

Reagents	Pounds per ton	
	Rougher	Cleaner
SO_2 for pH of 6.0	2.0 #/T	
Emulsion Composition	25.0 #/T	
25% Diesel Oil #2	6.25#/T	
65% Aliphat 44-E	16.25#/T	
10% Oronite	2.5 #/T	

Products	Wt	% Wt	Assays		Recovery	
			% Mn	% Insol	% Mn	% Insol
Cl. Conc.	119.0	30.2	24.4	38.2	82.1	16.0
Middling	86.5	21.9	4.5	80.3	10.9	24.4
Tailing	188.8	47.9	1.3	89.5	7.0	59.6
Head calc.	394.3	100.0			100.0	100.0
Head assay			9.2	71.0		

Initial...pH- 8.2 Remarks:

SO_2.....pH- 5.9

Emulsion..pH- 7.0

Final.....pH-

Test: 8015

Ore: Natural

Grind:	Mill	Time	Mesh	Percent Solids
	Pulverizer	min	All -65	100 %

Fagergren Flotation Machines:	Conditioned	Floated
	5 min at 2200 rpm	at 1220 rpm

Reagents	Pounds per ton	
	Rougher	Cleaner
HF for pH of 6.5		
Emulsion Composition	25.0 #/T	
19% Diesel Oil #2	4.75#/T	
80% Aliphat 44-E	20.0 #/T	
1% Oronite	0.25#/T	

Products	Wt	% Wt	Assays		Recovery	
			% Mn	% Insol	% Mn	% Insol
Cl. Conc.	156.5	39.9	18.7	50.0	87.0	27.6
Middling	117.5	30.0	2.4	87.0	8.4	36.3
Tailing	118.0	30.1	1.3	86.2	4.6	36.1
Head calc.	392.0	100.0			100.0	100.0
Head assay			9.2	71.0		

Initial...pH-8.1 Remarks:

HF.....pH-6.5

Emulsion..pH-7.3

Final.....pH-

Test: 8016

Ore: Natural

Grind:	Mill	Time	Mesh	Percent Solids
	Pulverizer	min	All -65	100 %

Fagergren Flotation Machines:	Conditioned	Floated
	5 min at 2200 rpm	at 1220 rpm

Reagents	Pounds per ton	
	Rougher	Cleaner
HF for pH of 6.5		
Emulsion Composition	25.0 #/T	
20% Diesel Oil #2	5.0 #/T	
75% Aliphat 44-E	18.75#/T	
5% Oronite	1.25#/T	

Products	Wt	% Wt	Assays		Recovery	
			% Mn	% Insol	% Mn	% Insol
Cl. Conc.	134.7	34.2	23.2	43.0	86.6	20.4
Middling	79.5	20.2	3.3	83.6	7.3	23.5
Tailing	178.3	45.6	1.2	88.2	6.1	56.1
Head calc.	392.5	100.0			100.0	100.0
Head assay			9.2	71.0		

Initial...pH- 8.0 Remarks:

HF.....pH- 6.5

Emulsion..pH- 8.0

Final.....pH- 7.5

Test: 8C17

Ore: Natural

Grind:	Mill	Time	Mesh	Percent Solids
	Pulverizer	min	All -65	100 %

Fagergren Flotation Machines:	Conditioned	Floated
	5 min at 2200 rpm	at 1220 rpm

Reagents	Pounds per ton	
	Rougher	Cleaner
HF for pH of 6.5		
Emulsion Composition	25.0 #/T	
15% Diesel Oil #2	3.75#/T	
75% Aliphat 44-E	18.75#/T	
10% Oronite	2.5 #/T	

Products	Wt	% Wt	Assays		Recovery	
			% Mn	% Insol	% Mn	% Insol
Cl. Conc.	126.6	31.6	24.2	39.1	82.5	17.3
Middling	71.3	17.8	4.1	79.2	7.9	19.9
Tailing	201.1	50.6	1.8	88.3	9.6	62.8
Head calc.	399.0	100.0			100.0	100.0
Head assay			9.2	71.0		

Initial...pH-8.1 Remarks:

HF.....pH-6.5

Emulsion..pH-7.9

Final.....pH-7.2

Test: 8021

Ore: Natural

Grind:	Mill	Time	Mesh	Percent Solids
	Pulverizer	min	All -65	100 %

Fagergren Flotation Machines:	Conditioned 5 min at 2200 rpm	Floated at 1220 rpm

Reagents	Pounds per ton	
	Rougher	Cleaner
HF for pH of 6.5		
Emulsion Composition	25.0 #/T	
20% Diesel Oil #2	5.0 #/T	
80% Aliphat 44-E	20.0 #/T	

Products	Wt	% Wt	Assays		Recovery	
			% Mn	% Insol	% Mn	% Insol
Cl. Conc.	121.4	31.2	24.6	37.9	83.8	16.8
Middling	116.4	29.9	3.4	81.7	11.1	34.7
Tailing	152.0	38.9	1.2	87.6	5.1	48.5
Head calc.	389.8	100.0			100.0	100.0
Head assay			9.2	71.0		

Initial...pH-8.0

HF.....pH-6.6

Emulsion..pH-7.4

Final.....pH-7.4

Remarks: Pulp flocculated without Oronite.

Test: 8022

Ore: Natural

Grind:	Mill	Time	Mesh	Percent Solids
	Pulverizer	min	All -65	100 %

Fagergren Flotation Machines:	Conditioned	Floated
	5 min at 2200 rpm	at 1220 rpm

Reagents	Pounds per ton	
	Rougher	Cleaner
HF for pH of 6.5		
Emulsion Composition	25.0 #/T	
17% Diesel Oil #2	4.25#/T	
82.5% Aliphat 44-E	20.6 #/T	
0.5% Oronite	0.12#/T	

Products	Wt	% Wt	Assays		Recovery	
			% Mn	% Insol	% Mn	% Insol
Cl. Conc.	119.6	29.8	26.4	33.7	84.0	14.4
Middling	96.5	24.0	3.7	81.0	9.6	27.9
Tailing	185.0	46.2	1.3	86.7	6.4	57.7
Head calc.	401.1	100.0			100.0	100.0
Head assay			9.2	71.0		

Initial...pH-3.1 Remarks:

HF.....pH-6.5

Emulsion..pH-7.6

Final.....pH-7.4

Test: 8023

Ore: Natural

Grind:	Mill	Time	Mesh	Percent Solids
	Pulverizer	min	All -65	100 %

Fagergren Flotation Machines:	Conditioned	Floated
	5 min at 2200 rpm	at 1220 rpm

Reagents	Pounds per ton	
	Rougher	Cleaner
HF for pH of 6.5		
Emulsion Composition	25.0 #/T	
21% Diesel Oil #2	5.25#/T	
77% Aliphat 44-E	19.25#/T	
2% Oronite	0.5 #/T	

Products	Wt	% Wt	Assays		Recovery	
			% Mn	% Insol	% Mn	% Insol
Cl. Conc.	140.2	35.8	22.8	44.8	86.6	22.2
Middling	109.1	27.9	2.8	86.9	8.3	33.4
Tailing	142.6	36.3	1.3	88.1	5.1	44.4
Head calc.	391.9	100.0			100.0	100.0
Head assay			9.2	71.0		

Initial...pH-8.2 Remarks:

HF.....pH-6.5

Emulsion..pH-7.4

Final.....pH-

Test: 8024

Ore: Concentrates

Grind:	Mill	Time	Mesh	Percent Solids
	Pulverizer	min	All -65	100 %
	Rod	10 "		50 "
Fagergren Flotation Machines:		Conditioned 0 min at 2200 rpm		Floated at 1220 rpm

Reagents	Pounds per ton	
	Rougher	Cleaner
HF for pH of 6.5		
Emulsion Composition	10.0 #/T	
19% Diesel Oil #2	1.9 #/T	
80% Aliphat 44-E	8.0 #/T	
1% Oronite	0.1 #/T	

Products	Wt	% Wt	Assays		Recovery	
			% Mn	% Insol	% Mn	% Insol
Cl. Conc.						
Middling						
Tailing						
Head calc.						
Head assay						

Initial...pH-7.6

HF.....pH-6.4

Emulsion..pH-7.4

Final.....pH-6.9

Remarks: All of the pulp floated.

Appendix IV

Flotation Tests of Wet-Ground Natural Ore

Test: 8027

Ore: Natural

Grind:	Mill	Time	Mesh	Percent Solids
	Rod	15 min	All -100	50 %

Fagergren Flotation Machines:	Conditioned	Floated
	5 min at 2200 rpm	at 1220 rpm

Reagents	Pounds per ton	
	Rougher	Cleaner
HF for pH of 6.5		
Emulsion Composition	10.0 #/T	
20% Diesel Oil #2	2.0 #/T	
80% Aliphat 44-E	8.0 #/T	

Products	Wt	% Wt	Assays		Recovery	
			% Mn	% Insol	% Mn	% Insol
Cl. Conc.	48.6	11.9	31.9	26.5	41.0	4.5
Middling	183.8	44.8	8.2	72.8	39.8	46.4
Tailing	176.6	43.3	4.1	79.7	19.2	49.1
Head calc.	409.0	100.0			100.0	100.0
Head assay			9.2	71.0		

Initial...pH- 8.3 Remarks:

HF.....pH- 6.5

Emulsion..pH- 6.8

Final.....pH- 7.3

Test: 8026

Ore: Natural

Grind:	Mill	Time	Mesh	Percent Solids
	Rod	15 min	All -100	50 %

Fagergren Flotation Machines:	Conditioned	Floated
	5 min at 2200 rpm	at 1220 rpm

Reagents	Pounds per ton	
	Rougher	Cleaner
HF for pH of 6.5		
Emulsion Composition	15.0 #/T	
20% Diesel Oil #2	3.0 #/T	
80% Aliphat 44-E	12.0 #/T	

Products	Wt	% Wt	Assays		Recovery	
			% Mn	% Insol	% Mn	% Insol
Cl. Conc.	81.9	20.6	25.2	34.4	57.0	10.2
Middling	146.9	36.8	6.3	76.4	25.6	40.5
Tailing	169.2	42.6	3.7	80.2	17.4	49.3
Head calc.	398.0	100.0			100.0	100.0
Head assay			9.2	71.0		

Initial...pH-8.2

HF.....pH-6.2

Emulsion..pH-6.7

Final.....pH-7.1

Remarks: Poor flocs.

Test: 8025

Ore: Natural

Grind:	Mill	Time	Mesh	Percent Solids
	Rod	15 min	All -100	50 %

Fagergren Flotation Machines:	Conditioned	Floated
	5 min at 2200 rpm	at 1220 rpm

Reagents	Pounds per ton	
	Rougher	Cleaner
HF for pH of 6.5		
Emulsion Composition	20.0 #/T	
20% Diesel Oil #2	4.0 #/T	
80% Aliphat 44-E	16.0 #/T	

Products	Wt	% Wt	Assays		Recovery	
			% Mn	% Insol	% Mn	% Insol
Cl. Conc.	84.8	21.4	28.0	30.6	65.0	9.3
Middling	146,9	37.1	5.6	80.6	22.8	41.3
Tailing	164.0	41.5	2.7	86.0	12.2	49.4
Head calc.	395.7	100.0			100.0	100.0
Head assay			9.2	71.0		

Initial...pH-8.1

HF.....pH-6.4

Emulsion..pH-7.3

Final.....pH-7.3

Remarks: Good end point in float.

Test: 8028

Ore: Natural

Grind: Mill: Rod; Time: 15 min; Mesh: All -100; Percent Solids: 50 %

Fagergren Flotation Machines: Conditioned 5 min at 2200 rpm; Floated at 1220 rpm

Reagents	Pounds per ton	
	Rougher	Cleaner
HF for pH of 6.5		
Emulsion Composition	25.0 #/T	
20% Diesel Oil #2	5.0 #/T	
80% Aliphat 44-E	20.0 #/T	

Products	Wt	% Wt	Assays		Recovery	
			% Mn	% Insol	% Mn	% Insol
Cl. Conc.	69.6	17.3	27.6	26.0	55.1	6.5
Middling	143.5	35.6	7.5	75.0	36.8	37.4
Tailing	189.0	47.1	2.6	85.3	14.1	56.1
Head calc.	402.1	100.0			100.0	100.0
Head assay			9.2	71.0		

Initial...pH-8.0 Remarks:

HF.....pH-6.5

Emulsion..pH-7.5

Final.....pH-7.5

Test: 8044

Ore: Natural

Grind:	Mill	Time	Mesh	Percent Solids
	Rod	15 min	All - 100	50 %

Fagergren Flotation Machines:	Conditioned	Floated
	5 min at 2200 rpm	at 1220 rpm

Reagents	Pounds per ton	
	Rougher	Cleaner
HF for pH of 6.5		
Emulsion Composition	30.0 #/T	
20% Diesel Oil #2	6.0 #/T	
80% Aliphat 44-E	24.0 #/T	

Products	Wt	% Wt	Assays		Recovery	
			% Mn	% Insol	% Mn	% Insol
Cl. Conc.	155.5	39.1	17.5	52.3	76.5	29.4
Middling	153.2	38.5	4.0	80.5	17.2	44.5
Tailing	89.3	22.4	2.5	81.0	6.3	26.1
Head calc.	398.0	100.0			100.0	100.0
Head assay			9.2	71.0		

Initial...pH-8.1 Remarks:

HF.....pH-6.5

Emulsion..pH-6.7

Final.....pH-6.9

Test: 8043

Ore: Natural

Grind:	Mill	Time	Mesh	Percent Solids
	Rod	15 min	All -100	50 %

Fagergren Flotation Machines:	Conditioned	Floated
	5 min at 2200 rpm	at 1220 rpm

Reagents	Pounds per ton	
	Rougher	Cleaner
HF for pH of 6.5		
Emulsion Composition	40.0 #/T	
20% Diesel Oil #2	8.0 #/T	
80% Aliphat 44-E	32.0 #/T	

Products	Wt	% Wt	Assays		Recovery	
			% Mn	% Insol	% Mn	% Insol
Cl. Conc.	147.2	37.3	20.0	46.2	81.3	25.6
Middling	140.5	35.6	3.6	82.6	14.0	43.3
Tailing	106.6	27.1	1.6	77.8	4.7	31.1
Head calc.	394.3	100.0			100.0	100.0
Head assay			9.2	71.0		

Initial...pH- 8.4 Remarks:

HF.....pH- 6.5

Emulsion..pH- 6.8

Final.....pH- 6.7

Test: 8035

Ore: Natural

Grind:	Mill	Time	Mesh	Percent Solids
	Rod	15 min	All -100	50 %

Fagergren Flotation Machines:	Conditioned	Floated
	5 min at 2200 rpm	at 1220 rpm

Reagents	Pounds per ton	
	Rougher	Cleaner
HF for pH of 6.5		
Emulsion Composition	50.0 #/T	
20% Diesel Oil #2	10.0 #/T	
80% Aliphat 44-E	40.0 #/T	

Products	Wt	% Wt	Assays		Recovery	
			% Mn	% Insol	% Mn	% Insol
Cl. Conc.	102.3	26.2	27.8	31.3	78.4	11.5
Middling	145.8	37.3	4.0	84.4	16.1	43.7
Tailing	142.5	36.5	1.4	88.4	5.5	45.8
Head calc.	390.6	100.0			100.0	100.0
Head assay			9.2	71.0		

Initial...pH-8.1 Remarks:

HF.....pH-6.5

Emulsion..pH-8.2

Final.....pH-7.8

Test: 8042

Ore: Natural

Grind:	Mill	Time	Mesh	Percent Solids
	Rod	15 min	All -100	50 %

Fagergren Flotation Machines:	Conditioned	Floated
	5 min at 2200 rpm	at 1220 rpm

Reagents	Pounds per ton	
	Rougher	Cleaner
HF for pH of 6.5		
Emulsion Composition	50.0 #/T	
20% Diesel Oil #2	10.0 #/T	
80% Aliphat 44-E	40.0 #/T	

Products	Wt	% Wt	Assays		Recovery	
			% Mn	% Insol	% Mn	% Insol
Cl. Conc.	194.4	49.4	16.2	54.1	88.5	38.2
Middling	134.4	34.2	2.1	86.0	8.0	42.1
Tailing	64.6	16.4	1.9	83.9	3.5	19.7
Head calc.	393.4	100.0			100.0	100.0
Head assay			9.2	71.0		

Initial...pH- 8.4 Remarks:

HF.....pH- 6.5

Emulsion..pH- 7.3

Final.....pH- 7.3

Test: 8040

Ore: Natural

Grind:	Mill	Time	Mesh	Percent Solids
	Rod	15 min	All -100	50 %

Fagergren Flotation Machines:	Conditioned	Floated
	5 min at 2200 rpm	at 1220 rpm

Reagents	Pounds per ton	
	Rougher	Cleaner
HF for pH of 6.5		
Emulsion Composition	60.0 #/T	
20% Diesel Oil #2	12.0 #/T	
80% Aliphat 44-E	48.0 #/T	

Products	Wt	% Wt	Assays		Recovery	
			% Mn	% Insol	% Mn	% Insol
Cl. Conc.	182.8	45.7	16.8	47.5	90.7	31.5
Middling	151.1	37.8	1.7	87.8	7.6	48.2
Tailing	66.0	16.5	0.9	85.2	1.7	20.3
Head calc.	399.0	100.0			100.0	100.0
Head assay			9.2	71.0		

Initial...pH-8.4 Remarks:

HF.....pH-6.3

Emulsion..pH-7.7

Final.....pH-7.3

Test: 8038

Ore: Natural

Grind:	Mill	Time	Mesh	Percent Solids
	Rod	15 min	All -100	50 %

Fagergren Flotation Machines:	Conditioned	Floated
	5 min at 2200 rpm	at 1220 rpm

Reagents	Pounds per ton	
	Rougher	Cleaner
HF for pH of 6.5		
Emulsion Composition	75.0 #/T	
20% Diesel Oil #2	15.0 #/T	
80% Aliphat 44-E	60.0 #/T	

Products	Wt	% Wt	Assays		Recovery	
			% Mn	% Insol	% Mn	% Insol
Cl. Conc.	215.8	54.2	16.2	54.0	93.5	42.5
Middling	128.8	32.4	1.5	37.3	5.1	40.8
Tailing	53.0	13.4	1.1	35.6	1.4	16.7
Head calc.	397.6	100.0			100.0	100.0
Head assay			9.2	71.0		

Initial...pH-8.5 Remarks:

HF.....pH-6.5

Emulsion..pH-8.4

Final.....pH-8.0

Test: 8039

Ore: Natural

Grind:	Mill	Time	Mesh	Percent Solids
	Rod	15 min	All -100	50 %

Fagergren Flotation Machines:	Conditioned	Floated
	5 min at 2200 rpm	at 1220 rpm

Reagents	Pounds per ton	
	Rougher	Cleaner
HF for pH of 6.5		
Emulsion Composition	100.0 #/T	
20% Diesel Oil #2	20.0 #/T	
80% Aliphat 44-E	80.0 #/T	

Products	Wt	% Wt	Assays		Recovery	
			% Mn	% Insol	% Mn	% Insol
Cl. Conc.	210.6	52.3	16.9	52.2	93.1	39.8
Middling	107.9	26.7	1.7	86.7	4.7	33.8
Tailing	84.7	21.0	1.0	86.3	2.2	26.4
Head calc.	403.2	100.0			100.0	100.0
Head assay			9.2	71.0		

Initial...pH-3.4 Remarks:

HF.....pH-6.5

Emulsion..pH-3.2

Final.....pH-3.0

Test: 8C34

Ore: Natural, 173 g of concentrates

Grind:	Mill	Time	Mesh	Percent Solids
	Rod	5 min	All -	50 %

Fagergren Flotation Machines:	Conditioned	Floated
	5 min at 2200 rpm	at 1220 rpm

Reagents	Pounds per ton	
	Rougher	Cleaner
HF for pH of 6.5		
Emulsion Composition	57.5 #/T	
20% Diesel Oil #2	11.5 #/T	
80% Aliphat 44-E	46.0 #/T	

Products	Wt	% Wt	Assays		Recovery	
			% Mn	% Insol	% Mn	% Insol
Cl. Conc.	105.7	63.9	30.0	24.6	69.8	53.5
Middling	43,4	26.2	24.0	36.0	22.9	32.1
Tailing	16.4	9.9	20.0	42.0	7.3	14.4
Head calc.	165.5	100.0			100.0	100.0
Head assay						

Initial...pH-8.3

HF.....pH-6.5

Emulsion..pH-8.4

Final.....pH-7.6

Remarks: Only two cleaners were conducted.

Appendix V

Flotation Tests of Reduction-Roasted Ore

Test: 8010

Ore: Reduction Roasted

Grind:	Mill	Time	Mesh	Percent Solids
	Pulverizer	min	All -65	100 %

Fagergren Flotation Machines:	Conditioned	Floated
	6 min at 2200 rpm	at 1220 rpm

Reagents	Pounds per ton	
	Rougher	Cleaner
HF for pH of 6.5		
Emulsion Composition	25.0 #/T	
15% Diesel Oil #2	3.75#/T	
80% Aliphat 44-E	20.0 #/T	
5% Oronite	1.25#/T	

Products	Wt	% Wt	Assays		Recovery	
			% Mn	% Insol	% Mn	% Insol
Cl. Conc.	111.9	28.0	20.1	53.7	58.6	20.1
Middling	166.6	41.6	7.5	78.6	32.5	43.8
Tailing	121.8	30.4	2.8	88.5	8.9	36.1
Head calc.	400.3	100.0			100.0	100.0
Head assay			9.0	74.4		

Initial...pH-9.5

HF.....pH-6.3

Emulsion..pH-8.0

Final.....pH-6.0

Remarks: The pH was lowered to 6.0 after the emulsion had been added by the addition of more HF.

Test: 8011

Ore: Reduction Roasted

Grind:	Mill	Time	Mesh	Percent Solids
	Pulverizer	min	All -65	100 %

Fagergren Flotation Machines:	Conditioned	Floated
	5 min at 2200 rpm	at 1220 rpm

Reagents	Pounds per ton	
	Rougher	Cleaner
HF for pH of 6.5		
Emulsion Composition	25.0 #/T	
20% Diesel Oil #2	5.0 #/T	
60% Aliphat 44-E	15.0 #/T	
20% Oronite	5.0 #/T	

Products	Wt	% Wt	Assays		Recovery	
			% Mn	% Insol	% Mn	% Insol
Cl. Conc.	30.3	7.6	28.2	29.2	23.6	2.9
Middling	75,5	18.9	12.1	66.9	25.2	18.9
Tailing	293.0	73.5	6.3	81.4	51.2	79.2
Head calc.	398.8	100.0			100.0	100.0
Head assay			9.0	74.4		

Initial...pH-9.3 Remarks:

HF.....pH-6.0

Emulsion..pH-7.4

Final.....pH-8.0

Test: 8012

Ore: Reduction Roasted

Grind:	Mill	Time	Mesh	Percent Solids
	Pulverizer	min	All -65	100 %

Fagergren Flotation Machines:	Conditioned	Floated
	5 min at 2200 rpm	at 1220 rpm

Reagents	Pounds per ton	
	Rougher	Cleaner
HF for pH of 6.5		
Emulsion Composition	25.0 #/T	
35% Diesel Oil #2	8.75#/T	
60% Aliphat 44-E	15.0 #/T	
5% Cronite	1.25#/T	

Products	Wt	% Wt	Assays		Recovery	
			% Mn	% Insol	% Mn	% Insol
Cl. Conc.	61.2	15.2	24.6	40.1	40.7	8.2
Middling	149.5	37.2	9.2	74.9	37.1	37.1
Tailing	190.8	47.6	4.3	86.2	22.2	54.7
Head calc.	401.5	100.0			100.0	100.0
Head assay			9.0	74.4		

Initial...pH- 9.3 Remarks:

HF.....pH- 6.0

Emulsion..pH- 8.4

Final.....pH- 8.0

Test: 8013

Ore: Reduction Roasted .

Grind:	Mill	Time	Mesh	Percent Solids
	Pulverizer	min	All -65	100 %

Fagergren Flotation Machines:	Conditioned	Floated
	5 min at 2200 rpm	at 1220 rpm

Reagents	Pounds per ton	
	Rougher	Cleaner
HF for pH of 6.5		
Emulsion Composition	25.0 #/T	
40% Diesel Oil #2	10.0 #/T	
35% Aliphat 44-E	8.75#/T	
25% Oronite	6.25#/T	

Products	Wt	% Wt	Assays		Recovery	
			% Mn	% Insol	% Mn	% Insol
Cl. Conc.	32.1	8.0	26.6	31.5	22.7	3.3
Middling	50.2	12.5	12.0	66.0	16.0	10.3
Tailing	317.8	79.5	7.2	81.3	61.3	85.9
Head calc.	400.1	100.0			100.0	100.0
Head assay			9.0	74.4		

Initial...pH- 9.1 Remarks:

HF.....pH- 6.0

Emulsion..pH- 7.4

Final.....pH- 8.0

Test: 8014

Ore: Reduction Roasted

Grind:	Mill	Time	Mesh	Percent Solids
	Pulverizer	min	All -65	100 %

Fagergren Flotation Machines:	Conditioned	Floated
	5 min at 2200 rpm	at 1220 rpm

Reagents	Pounds per ton	
	Rougher	Cleaner
for pH of	None	
Emulsion Composition	25.0 #/T	
75% Diesel Oil #2	18.75#/T	
15% Aliphat 44-E	3.75#/T	
10% Oronite	2.5 #/T	

Products	Wt	% Wt	Assays		Recovery	
			% Mn	% Insol	% Mn	% Insol
Cl. Conc.	21.0	5.2	21.5	36.0	12.6	2.5
Middling	120.7	29.9	13.3	65.7	45.0	26.0
Tailing	261.1	64.9	5.8	83.0	42.4	71.5
Head calc.	402.8	100.0			100.0	100.0
Head assay			9.0	74.4		

Initial...pH-9.5

pH-

Emulsion..pH-9.8

Final.....pH-

Remarks: Float was conducted at natural pulp pH.

Test: 8018

Ore: Reduction Roasted

Grind:	Mill	Time	Mesh	Percent Solids
	Pulverizer	min	All -65	100 %

Fagergren Flotation Machines:	Conditioned	Floated
	5 min at 2200 rpm	at 1220 rpm

Reagents	Pounds per ton	
	Rougher	Cleaner
HF for pH of 6.5		
Emulsion Composition	None	
Oleic Acid	2.2 #/T	
Diesel Oil #2	4.5 #/T	

Products	Wt	% Wt	Assays		Recovery	
			% Mn	% Insol	% Mn	% Insol
Cl. Conc.	72.0	18.3	23.9	44.3	46.5	11.1
Middling	122.4	31.1	7.9	73.8	26.1	31.6
Tailing	198.5	50.6	5.1	82.6	27.4	57.3
Head calc.	392.9	100.0			100.0	100.0
Head assay			9.0	74.4		

Initial...pH-8.7

HF.....pH-6.1

Emulsion..pH-

Final.....pH-6.3

Remarks: This tests had the concentrate cleaned twice.

Test: 8019

Ore: Reduction Roasted

Grind:	Mill	Time	Mesh	Percent Solids
	Pulverizer	min	All -65	100 %

Fagergren Flotation Machines:	Conditioned	Floated
	0 min at 2200 rpm	at 1220 rpm

Reagents	Pounds per ton	
	Rougher	Cleaner
HF for pH of 6.5		
Emulsion Composition	None	
Potassium Sulfate	8.0 #/T	
Sodium Oxalate	4.0 #/T	
Oleic Acid	1.1 #/T	

Products	Wt	% Wt	Assays		Recovery	
			% Mn	% Insol	% Mn	% Insol
Cl. Conc.	22.4	5.6	24.2	29.8	15.4	2.3
Middling	52.2	13.0	18.0	55.0	26.5	9.8
Tailing	325.6	81.4	6.3	79.4	58.1	87.9
Head calc.	400.2	100.0			100.0	100.0
Head assay			9.0	74.4		

Initial...pH-8.8

HF.....pH-6.5

Emulsion..pH-6.8

Final.....pH-7.0

Remarks: Test was only cleaned once.

Test: 8020

Ore: Reduction Roasted

Grind:	Mill	Time	Mesh	Percent Solids
	Pulverizer	min	All -65	100 %

Fagergren Flotation Machines:	Conditioned	Floated
	0 min at 2200 rpm	at 1220 rpm

Reagents	Pounds per ton	
	Rougher	Cleaner
HF for pH of 6.5		
Emulsion Composition	None	
Oleic Acid	2.2 #/T	
Diesel Oil #2	6.0 #/T	
Sodium Oxalate	5.0 #/T	

Products	Wt	% Wt	Assays		Recovery	
			% Mn	% Insol	% Mn	% Insol
Cl. Conc.	31.6	8.0	30.5	25.8	27.0	2.9
Middling	107.7	27.0	13.8	62.0	41.3	23.0
Tailing	259.8	65.0	4.4	83.4	31.7	74.1
Head calc.	399.1	100.0			100.0	100.0
Head assay			9.0	74.4		

Initial...pH-8.8 Remarks:

HF.....pH-6.5

Emulsion..pH-6.7

Final.....pH-7.1

Test: 8029

Ore: Reduction Roasted

Grind:	Mill	Time	Mesh	Percent Solids
	Pulverizer	min	All -65	100 %

Fagergren Flotation Machines:	Conditioned	Floated
	5 min at 2200 rpm	at 1220 rpm

Reagents	Pounds per ton	
	Rougher	Cleaner
HF for pH of 6.5		
Emulsion Composition	25.0 #/T	
20% Diesel Oil #2	5.0 #/T	
79% Aliphat 44-E	19.75#/T	
1% Oronite	0.25#/T	

Products	Wt	% Wt	Assays		Recovery	
			% Mn	% Insol	% Mn	% Insol
Cl. Conc.	30.6	7.7	33.9	21.0	29.9	2.2
Middling	109.9	27.8	14.4	61.4	45.7	23.0
Tailing	254.9	64.5	3.3	86.3	24.4	74.8
Head calc.	395.4	100.0			100.0	100.0
Head assay			9.0	74.4		

Initial...pH-8.4

HF.....pH-6.4

Emulsion..pH-8.3

Final.....pH-7.8

Remarks: Considerable manganese was dropped in the 3rd and 4th cleaners.

Test: 8030

Ore: Reduction Roasted

Grind:	Mill	Time	Mesh	Percent Solids
	Pulverizer	min	All -65	100 %

	Conditioned	Floated
Fagergren Flotation Machines:	5 min at 2200 rpm	at 1220 rpm

Reagents	Pounds per ton	
	Rougher	Cleaner
HF for pH of 6.5		
Emulsion Composition	25.0 #/T	
20% Diesel Oil #2	5.0 #/T	
80% Aliphat 44-E	20.0 #/T	

Products	Wt	% Wt	Assays		Recovery	
			% Mn	% Insol	% Mn	% Insol
Cl. Conc.	14.1	3.6	31.7	19.8	12.9	1.0
Middling	185.1	46.7	13.1	66.1	69.6	41.2
Tailing	196.8	49.7	3.1	87.4	17.5	57.8
Head calc.	396.0	100.0			100.0	100.0
Head assay			9.0	74.4		

Initial...pH-8.5

HF.....pH-6.4

Emulsion..pH-8.2

Final.....pH-7.3

Remarks: Considerable manganese was dropped in the 3rd and 4th cleaners. The pH was lowered to 7.0 after the emulsion had been added.

Test: 8031

Ore: Reduction Roasted

Grind:	Mill	Time	Mesh	Percent Solids
	Pulverizer	min	All -65	100 %

Fagergren Flotation Machines:	Conditioned	Floated
	5 min at 2200 rpm	at 1220 rpm

Reagents	Pounds per ton	
	Rougher	Cleaner
HF for pH of 6.5		
Emulsion Composition	20.0 #/T	
20% Diesel Oil #2	4.0 #/T	
80% Aliphat 44-E	16.0 #/T	
$MgCl_2$	10.0 #/T	

Products	Wt	% Wt	Assays		Recovery	
			% Mn	% Insol	% Mn	% Insol
Cl. Conc.	24.4	6.1	29.5	25.4	20.0	2.1
Middling	178.6	44.6	10.8	71.0	53.6	43.0
Tailing	196.7	49.3	4.8	82.4	26.4	54.9
Head calc.	399.7	100.0			100.0	100.0
Head assay			9.0	74.4		

Initial...pH-8.7

HF.....pH-6.3

Emulsion..pH-7.7

Final.....pH-7.8

Remarks: Magnesium chloride was added after the acid to determine if the system could be resensitized by the addition of a metal ion.

Test: 8032

Ore: Reduction Roasted

Grind:	Mill	Time	Mesh	Percent Solids
	Pulverizer	min	All -65	100 %

Fagergren Flotation Machines:	Conditioned	Floated
	5 min at 2200 rpm	at 1220 rpm

Reagents	Pounds per ton	
	Rougher	Cleaner
HF for pH of 6.5		
Emulsion Composition	20.0 #/T	
20% Diesel Oil #2	4.0 #/T	
80% Aliphat 44-E	16.0 #/T	
$SrCl_2$	10.0 #/T	

Products	Wt	% Wt	Assays		Recovery	
			% Mn	% Insol	% Mn	% Insol
Cl. Conc.	50.3	12.6	29.2	30.4	41.7	5.2
Middling	86.5	21.7	10.4	68.7	25.6	20.8
Tailing	263.3	65.7	4.5	80.6	33.7	74.0
Head calc.	400.1	100.0			100.0	100.0
Head assay			9.2	74.4		

Initial...pH-8.6

HF.....pH-6.5

Emulsion..pH-7.8

Final.....pH-7.9

Remarks: Strontium chloride was added after the acid to determine if the system could be resensitized by the addition of a metal ion.

Test: 8033

Ore: Reduction Roasted

Grind:	Mill	Time	Mesh	Percent Solids
	Pulverizer	min	All -65	100 %

Fagergren Flotation Machines:	Conditioned	Floated
	5 min at 2200 rpm	at 1220 rpm

Reagents	Pounds per ton	
	Rougher	Cleaner
HF for pH of 6.5		
Emulsion Composition	100.0 #/T	
20% Diesel Oil #2	20.0 #/T	
80% Aliphat 44-E	80.0 #/T	

Products	Wt	% Wt	Assays		Recovery	
			% Mn	% Insol	% Mn	% Insol
Cl. Conc.	41.3	10.1	26.4	25.3	31.6	3.5
Middling	74.0	18.2	13.6	61.3	29.3	15.3
Tailing	292.2	71.7	4.6	83.0	39.1	81.2
Head calc.	407.5	100.0			100.0	100.0
Head assay			9.0	74.4		

Initial...pH-8.8

HF.....pH-6.1

Emulsion..pH-9.1

Final.....pH-7.5

Remarks: The pH was lowered to 7.7 after the emulsion had been added.

Test: 8C36

Ore: Reduction Roasted

Grind:	Mill	Time	Mesh	Percent Solids
	Pulverizer	min	All -65	100 %
	Rod	5 "		50 "
Fagergren Flotation Machines:		Conditioned 7 min at 2200 rpm		Floated at 1220 rpm

Reagents	Pounds per ton	
	Rougher	Cleaner
for pH of	None	
Emulsion Composition	50.0 #/T	
20% Diesel Oil #2	10.0 #/T	
80% Aliphat 44-E	40.0 #/T	

Products	Wt	% Wt	Assays		Recovery	
			% Mn	% Insol	% Mn	% Insol
Cl. Conc.	47.6	12.1	31.3	24.1	41.7	3.9
Middling	71.3	18.1	9.5	72.7	19.0	17.9
Tailing	275.0	69.8	5.1	82.8	39.3	78.2
Head calc.	393.9	100.0			100.0	100.0
Head assay			9.0	74.4		

Initial...pH-8.6 Remarks: No pH ajustment.

pH-

Emulsion..pH-9.4

Final.....pH-9.3

Test: 8037

Ore: Reduction Roasted

Grind:	Mill	Time	Mesh	Percent Solids
	Pulverizer	min	All -65	100 %
	Rod	5 "		50 "
Fagergren Flotation Machines:		Conditioned 0 min at 2200 rpm		Floated at 1220 rpm

Reagents	Pounds per ton	
	Rougher	Cleaner
for pH of	None	
Emulsion Composition	None	
Aliphat 44-E added to rod-mill	20.0 #/T	
Diesel Oil #2 to float-cell	5.0 #/T	

Products	Wt	% Wt	Assays		Recovery	
			% Mn	% Insol	% Mn	% Insol
Cl. Conc.	82.8	20.8	24.6	37.7	57.4	10.6
Middling	116.3	29.3	8.0	76.1	26.3	30.1
Tailing	198.3	49.9	2.9	87.8	16.3	59.3
Head calc.	397.4	100.0			100.0	100.0
Head assay			9.0	74.4		

Initial...pH- 9.3

pH-

Emulsion..pH-

Final.....pH- 9.1

Remarks: This test was conducted at the natural pH of the mineral pulp.

Test: 8041

Ore: Reduction Roasted

Grind:	Mill	Time	Mesh	Percent Solids
	Pulverizer	15 min	All -65	100 %
	Rod	10 "		50 "
Fagergren Flotation Machines:		Conditioned 5 min at 2200 rpm		Floated at 1220 rpm

Reagents	Pounds per ton	
	Rougher	Cleaner
HF for pH of 6.5		
Emulsion Composition	50.0 #/T	
20% Diesel Oil #2	10.0 #/T	
80% Aliphat 44-E	40.0 #/T	
$Na_2SiO_3 \cdot 5H_2O$ to 3rd cleaner		5.0 #/T

Products	Wt	% Wt	Assays		Recovery	
			% Mn	% Insol	% Mn	% Insol
Cl. Conc.	33.1	8.3	29.3	21.1	27.7	2.5
Middling	125.4	31.5	13.3	63.9	47.7	28.3
Tailing	239.4	60.2	3.6	85.0	24.6	79.2
Head calc.	397.9	100.0			100.0	100.0
Head assay			9.0	74.4		

Initial...pH-8.7

HF.....pH-6.4

Emulsion..pH-8.4

Final.....pH-7.6

Remarks: The sodium silicate depressed considerable manganese.

Appendix VI

Flotation Tests by a Cationic Collector

Test: C-1

Ore: Natural

Grind:	Mill	Time	Mesh	Percent Solids
	Rod	15 min	All -100	50 %

Fagergren Flotation Machines:	Conditioned 5 min at 2200 rpm	Floated at 1220 rpm

Reagents	Pounds per ton	
	Rougher	Cleaner
HF for pH of 6.0		
Emulsion Composition	20.0 #/T	
10% Diesel Oil #2	2.0 #/T	
80% Arquad #12	16.0 #/T	
10% Triethanolamine	2.0 #/T	

Products	Wt.	% Wt	Assays		Recovery	
			% Mn	% Insol	% Mn	% Insol
Cl. Conc.						
Middling						
Tailing						
Head calc.						
Head assay						

Initial...pH-8.2

HF.....pH-6.0

Emulsion..pH-7.4

Final.....pH-7.5

Remarks: Very stiff froth with no mineral load.

Test: C-2

Ore: Natural

Grind:	Mill	Time	Mesh	Percent Solids
	Rod	15 min	All -100	50 %

Fagergren Flotation Machines:	Conditioned	Floated
	5 min at 2200 rpm	at 1220 rpm

Reagents	Pounds per ton	
	Rougher	Cleaner
HF for pH of 6.0		
Emulsion Composition	20.00 #/T	
80% Diesel Oil #2	16.0 #/T	
10% Arquad #12	2.0 #/T	
10% Triethanolamine	2.0 #/T	

Products	Wt	% Wt	Assays		Recovery	
			% Mn	% Insol	% Mn	% Insol
Cl. Conc.						
Middling						
Tailing						
Head calc.						
Head assay						

Initial...pH-8.4

HF.....pH-6.0

Emulsion..pH-6.5

Final.....pH-7.0

Remarks: No breaking with very stiff froth.

Test: C-3

Ore: Natural

Grind:	Mill	Time	Mesh	Percent Solids
	Rod	15 min	All -100	50 %

Fagergren Flotation Machines:	Conditioned	Floated
	10 min at 2200 rpm	at 1220 rpm

Reagents	Pounds per ton	
	Rougher	Cleaner
HF for pH of 6.0		
Emulsion Composition	100.0 #/T	
80% Diesel Oil #2	80.0 #/T	
10% Arquad #12	10.0 #/T	
10% Triethanolamine	10.0 #/T	

Products	Wt	% Wt	Assays		Recovery	
			% Mn	% Insol	% Mn	% Insol
Cl. Conc.						
Middling						
Tailing						
Head calc.						
Head assay						

Initial...pH-8.3

HF.....pH-6.0

Emulsion..pH-7.9

Final.....pH-7.7

Remarks: Stiff froth with no mineral load.

Test: C-4

Ore: Natural

Grind:	Mill	Time	Mesh	Percent Solids
	Rod	15 min	All - 100	50 %

Fagergren Flotation Machines:	Conditioned	Floated
	10 min at 2200 rpm	at 1220 rpm

Reagents	Pounds per ton	
	Rougher	Cleaner
HF for pH of 6.0		
Emulsion Composition	100.0 #/T	
95% Diesel Oil #2	95.0 #/T	
5% Arquad #12	5.0 #/T	

Products	Wt	% Wt	Assays		Recovery	
			% Mn	% Insol	% Mn	% Insol
Cl. Conc.						
Middling						
Tailing						
Head calc.						
Head assay						

Initial...pH- 8.3 Remarks: Soft froth with no manganese.

HF.....pH- 6.0

Emulsion..pH- 6.0

Final.....pH-

Test: C-5

Ore: Natural

Grind:	Mill	Time	Mesh	Percent Solids
	Rod	15 min	All -100	50 %

Fagergren Flotation Machines:	Conditioned	Floated
	5 min at 2200 rpm	at 1220 rpm

Reagents	Pounds per ton	
	Rougher	Cleaner
KOH for pH of 9.5		
Emulsion Composition	20.0 #/T	
95% Diesel Oil #2	19.0 #/T	
5% Arquad #12	1.0 #/T	

Products	Wt	% Wt	Assays		Recovery	
			% Mn	% Insol	% Mn	% Insol
Cl. Conc.						
Middling						
Tailing						
Head calc.						
Head assay						

Initial...pH-8.3 Remarks: No froth.

KOH.....pH-9.5

Emulsion..pH-9.5

Final.....pH-9.3

Test: C-6

Ore: Natural

Grind:	Mill	Time	Mesh	Percent Solids
	Rod	15 min	All -100	50 %

Fagergren Flotation Machines:	Conditioned	Floated
	5 min at 2200 rpm	at 1220 rpm

Reagents	Pounds per ton	
	Rougher	Cleaner
HF for pH of 6.0		
Emulsion Composition	20.0 #/T	
98% Diesel Oil #2	19.6 #/T	
1% Arquad #12	0.2 #/T	
1% Triethanolamine	0.2 #/T	

Products	Wt	% Wt	Assays		Recovery	
			% Mn	% Insol	% Mn	% Insol
Cl. Conc.						
Middling						
Tailing						
Head calc.						
Head assay						

Initial...pH-8.2 Remarks: No froth.

HF.....pH-6.0

Emulsion..pH-6.5

Final.....pH-7.0

Test: C-7

Ore: Natural

Grind:	Mill	Time	Mesh	Percent Solids
	Rod	15 min	All -100	50 %

Fagergren Flotation Machines:	Conditioned	Floated
	4 min at 2200 rpm	at 1220 rpm

Reagents	Pounds per ton	
	Rougher	Cleaner
KOH for pH of 10.0		
Emulsion Composition	none	
Duomeen #12	2.0 #/T	
Diesel Oil #2	20.0 #/T	

Products	Wt	% Wt	Assays		Recovery	
			% Mn	% Insol	% Mn	% Insol
Cl. Conc.						
Middling						
Tailing						
Head calc.						
Head assay						

Initial...pH- 8.2

KOH..... pH- 10.0

Emulsion..pH-

Final.....pH- 9.9

Remarks: Poor froth and no lifting of the ore.

Test: C-8.

Ore: Natural

Grind:	Mill	Time	Mesh	Percent Solids
	Rod	15 min	All -100	50 %

Fagergren Flotation Machines:	Conditioned	Floated
	5 min at 2200 rpm	at 1220 rpm

Reagents	Pounds per ton	
	Rougher	Cleaner
KOH for pH of 11.0		
Emulsion Composition	none	
Duomeen #12	10.0 #/T	
Pine Oil	2 drops	

Products	Wt	% Wt	Assays		Recovery	
			% Mn	% Insol	% Mn	% Insol
Cl. Conc.						
Middling						
Tailing						
Head calc.						
Head assay						

Initial...pH- 8.2 Remarks: No manganese floated.

KOH..... pH- 11.0

Emulsion..pH-

Final.....pH- 10.8

Test: C-9

Ore: Natural

Grind:	Mill	Time	Mesh	Percent Solids
	Rod	15 min	All -100	50 %

Fagergren Flotation Machines:	Conditioned	Floated
	4 min at 2200 rpm	at 1220 rpm

Reagents	Pounds per ton	
	Rougher	Cleaner
HF for pH of 6.0		
Emulsion Composition	8.0 #/T	
62.5% Diesel Oil #2	5.0 #/T	
25.0% Arquad #12	2.0 #/T	
12.5% Triethanolamine	1.0 #/T	

Products	Wt	% Wt	Assays		Recovery	
			% Mn	% Insol	% Mn	% Insol
Cl. Conc.						
Middling						
Tailing						
Head calc.						
Head assay						

Initial...pH- 7.7 Remarks: Not enough reagent.

HF.....pH- 5.5

Emulsion..pH-

Final.....pH- 6.2

Test: C-10

Ore: Natural

Grind:	Mill	Time	Mesh	Percent Solids
	Rod	15 min	All -100	50 %

Fagergren Flotation Machines:	Conditioned	Floated
	10 min at 2200 rpm	at 1220 rpm

Reagents	Pounds per ton	
	Rougher	Cleaner
HF for pH of 6.0		
Emulsion Composition	100.0 #/T	
95% Diesel Oil #2	95.0 #/T	
4% Arquad #12	4.0 #/T	
1% Triethanolamine	1.0 #/T	

Products	Wt	% Wt	Assays		Recovery	
			% Mn	% Insol	% Mn	% Insol
Cl. Conc.						
Middling						
Tailing						
Head calc.						
Head assay						

Initial...pH-8.3

HF.....pH-6.0

Emulsion..pH-6.5

Final.....pH-7.4

Remarks: Fine bubbled froth, but no solids floated.

Test: C-11

Ore: Natural

Grind:	Mill	Time	Mesh	Percent Solids
	Rod	15 min	All -100	50 %

Fagergren Flotation Machines:	Conditioned	Floated
	6 min at 2200 rpm	at 1220 rpm

Reagents	Pounds per ton	
	Rougher	Cleaner
HF for pH of 6.0		
Emulsion Composition	100.0 #/T	
85% Diesel Oil #2	85.0 #/T	
14% Arquad #12	14.0 #/T	
1% Triethanolamine	1.0 #/T	

Products	Wt	% Wt	Assays		Recovery	
			% Mn	% Insol	% Mn	% Insol
Cl. Conc.						
Middling						
Tailing						
Head calc.						
Head assay						

Initial...pH-8.2 Remarks:

HF.....pH-5.8

Emulsion..pH-6.2

Final.....pH-6.7

Test: C-12

Ore: Natural

Grind:	Mill	Time	Mesh	Percent Solids
	Rod	15 min	All -100	50 %

Fagergren Flotation Machines:	Conditioned	Floated
	5 min at 2200 rpm	at 1220 rpm

Reagents	Pounds per ton	
	Rougher	Cleaner
HF for pH of 6.0		
Emulsion Composition	100.0 #/T	
60% Diesel Oil #2	60.0 #/T	
35% Arquad #12	35.0 #/T	
5% Triethanolamine	5.0 #/T	

Products	Wt	% Wt	Assays		Recovery	
			% Mn	% Insol	% Mn	% Insol
Cl. Conc.						
Middling						
Tailing						
Head calc.						
Head assay						

Initial...pH-8.2

HF.....pH-6.0

Emulsion..pH-7.1

Final.....pH-6.5

Remarks: Stiff froth.

Test: C-13

Ore: Natural

Grind:	Mill	Time	Mesh	Percent Solids
	Rod	15 min	All -100	50 %

Fagergren Flotation Machines:	Conditioned	Floated
	5 min at 2200 rpm	at 1220 rpm

Reagents	Pounds per ton	
	Rougher	Cleaner
HF for pH of 6.0		
Emulsion Composition	100.0 #/T	
30% Diesel Oil #2	30.0 #/T	
65% Arquad #12	65.0 #/T	
5% Triethanolamine	5.0 #/T	

Products	Wt	% Wt	Assays		Recovery	
			% Mn	% Insol	% Mn	% Insol
Cl. Conc.						
Middling						
Tailing						
Head calc.						
Head assay						

Initial...pH- 8.3 Remarks: Not saved for assay.

HF..... pH- 6.0

Emulsion..pH- 7.0.

Final.....pH- 7.0

Test: C-14

Ore: Natural

Grind:	Mill	Time	Mesh	Percent Solids
	Rod	15 min	All -100	50 %

Fagergren Flotation Machines:	Conditioned	Floated
	5 min at 2200 rpm	at 1220 rpm

Reagents	Pounds per ton	
	Rougher	Cleaner
HF for pH of 6.0		
Emulsion Composition	100.0 #/T	
40% Diesel Oil #2	40.0 #/T	
30% Arquad #12	30.0 #/T	
30% Triethanolamine	30.0 #/T	

Products	Wt	% Wt	Assays		Recovery	
			% Mn	% Insol	% Mn	% Insol
Cl. Conc.						
Middling						
Tailing						
Head calc.						
Head assay						

Initial...pH-8.3

HF.....pH-6.0

Emulsion..pH-8.4

Final.....pH-8.3

Remarks: Only slime was observed to be floated.

Test: C-15

Ore: Natural

Grind:	Mill	Time	Mesh	Percent Solids
	Rod	15 min	All -100	50 %

Fagergren Flotation Machines:	Conditioned	Floated
	5 min at 2200 rpm	at 1220 rpm

Reagents	Pounds per ton	
	Rougher	Cleaner
HF for pH of 6.0		
Emulsion Composition	100.0 #/T	
10% Diesel Oil #2	10.0 #/T	
45% Arquad #12	45.0 #/T	
45% Triethanolamine	45.0 #/T	

Products	Wt	% Wt	Assays		Recovery	
			% Mn	% Insol	% Mn	% Insol
Cl. Conc.						
Middling						
Tailing						
Head calc.						
Head assay						

Initial...pH-8.3

HF.....pH-6.0

Emulsion..pH-8.6

Final.....pH-8.5

Remarks: Considerable gangue floated, but very little manganese.

Test: C-16

Ore: Natural

Grind:	Mill	Time	Mesh	Percent Solids
	Rod	15 min	All -100	50 %

Fagergren Flotation Machines:	Conditioned	Floated
	5 min at 2200 rpm	at 1220 rpm

Reagents	Pounds per ton	
	Rougher	Cleaner
HF for pH of 6.0		
Emulsion Composition	100.0 #/T	
60% Diesel Oil #2	60.0 #/T	
5% Arquad #12	5.0 #/T	
35% Triethanolamine	35.0 #/T	

Products	Wt	% Wt	Assays		Recovery	
			% Mn	% Insol	% Mn	% Insol
Cl. Conc.						
Middling						
Tailing						
Head calc.						
Head assay						

Initial...pH- 8.5

HF..... pH- 6.0

Emulsion..pH- 8.4

Final.....pH- 8.5

Remarks: Being of very poor quality, this test was not saved for assay.

Test: C-17

Ore: Natural

Grind:	Mill	Time	Mesh	Percent Solids
	Rod	15 min	All -100	50 %

Fagergren Flotation Machines:	Conditioned	Floated
	5 min at 2200 rpm	at 1220 rpm

Reagents	Pounds per ton	
	Rougher	Cleaner
HF for pH of 6.0		
Emulsion Composition	100.0 #/T	
30% Diesel Oil #2	30.0 #/T	
5% Arquad #12	5.0 #/T	
65% Triethanolamine	65.0 #/T	

Products	Wt	% Wt	Assays		Recovery	
			% Mn	% Insol	% Mn	% Insol
Cl. Conc.						
Middling						
Tailing						
Head calc.						
Head assay						

Initial...pH- 8.5

HF.....pH- 5.5

Emulsion..pH- 8.7

Final.....pH- 8.6

Remarks: Being very poor, this test was not saved for assay.

Test: C-18

Ore: Natural

Grind:	Mill	Time	Mesh	Percent Solids
	Rod	15 min	All -100	50 %

Fagergren Flotation Machines:	Conditioned	Floated
	5 min at 2200 rpm	at 1220 rpm

Reagents	Pounds per ton	
	Rougher	Cleaner
HF for pH of 6.5		
Emulsion Composition	50.0 #/T	
20% Diesel Oil #2	10.0 #/T	
70% Aliphat 44-E	35.0 #/T	
10% Triethanolamine	5.0 #/T	

Products	Wt	% Wt	Assays		Recovery	
			% Mn	% Insol	% Mn	% Insol
Cl. Conc.	62.6	15.4	28.5	32.0	47.7	7.0
Middling	158.0	39.0	8.3	70.7	35.4	39.8
Tailing	184.5	45.6	3.4	81.2	16.9	53.2
Head calc.	405.1	100.0			100.0	100.0
Head assay			9.2	71.0		

Initial...pH-8.4 Remarks:

HF.....pH-6.5

Emulsion..pH-7.0

Final.....pH-6.3

Test: C-19

Ore: 40 g MnO_2(99.9%), 180 g SiO_2, and 180 g Celestite.

Grind:	Mill	Time	Mesh	Percent Solids
	Rod	5 min	All -	50 %

Fagergren Flotation Machines:	Conditioned	Floated
	5 min at 2200 rpm	at 1220 rpm

Reagents	Pounds per ton	
	Rougher	Cleaner
HF for pH of 6.0		
Emulsion Composition	50.0 #/T	
80% Diesel Oil #2	40.0 #/T	
15% Arquad #12	7.5 #/T	
5% Triethanolamine	2.5 #/T	

Products	Wt	% Wt	Assays		Recovery	
			% Mn	% Insol	% Mn	% Insol
Cl. Conc.	242.5	62.2	9.5	70.3	91.2	66.4
Middling						
Tailing	147.6	37.8	1.5	58.1	8.8	33.6
Head calc.	390.1				100.0	100.0
Head assay						

Initial...pH- 8.0

HF .....pH- 5.5

Emulsion..pH- 6.5

Final.....pH- 6.6

Remarks: A synthetic ore, which indicates that this emulsion will float commercial manganese.

Test: C-20

Ore: Reduction Roasted

Grind:	Mill	Time	Mesh	Percent Solids
	Pulverizer	min	All -65	100 %
	Rod	5 "		50 %
Fagergren Flotation Machines:		Conditioned 5 min at 2200 rpm		Floated at 1220 rpm

Reagents	Pounds per ton	
	Rougher	Cleaner
HF for pH of 6.5		
Emulsion Composition	50.0 #/T	
15% Diesel Oil #2	7.5 #/T	
75% Aliphat 44-E	37.5 #/T	
10% Triethanolamine	5.0 #/T	

Products	Wt	% Wt	Assays		Recovery	
			% Mn	% Insol	% Mn	% Insol
Cl. Conc.	34.8	8.8	30.4	20.0	29.3	2.5
Middling	87.0	21.9	17.2	57.4	41.2	17.0
Tailing	275.5	69.3	3.9	85.4	29.5	80.5
Head calc.	397.3	100.0			100.0	100.0
Head assay			9.0	74.4		

Initial...pH- 8.5 Remarks:

HF ..... pH- 6.7

Emulsion..pH- 8.2

Final.....pH- 8.0